PRINCIPLES OF AGRICULTURE

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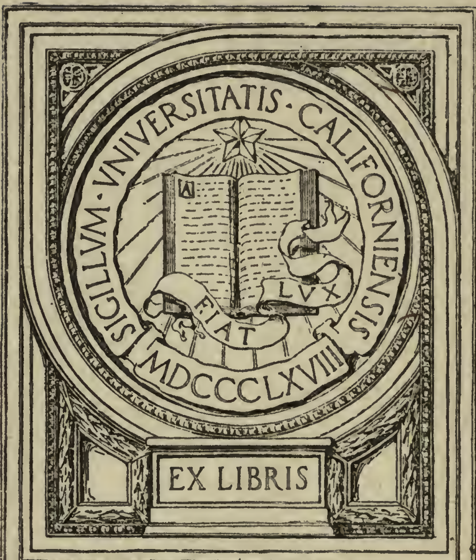
GEHRS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THE PRINCIPLES OF AGRICULTURE

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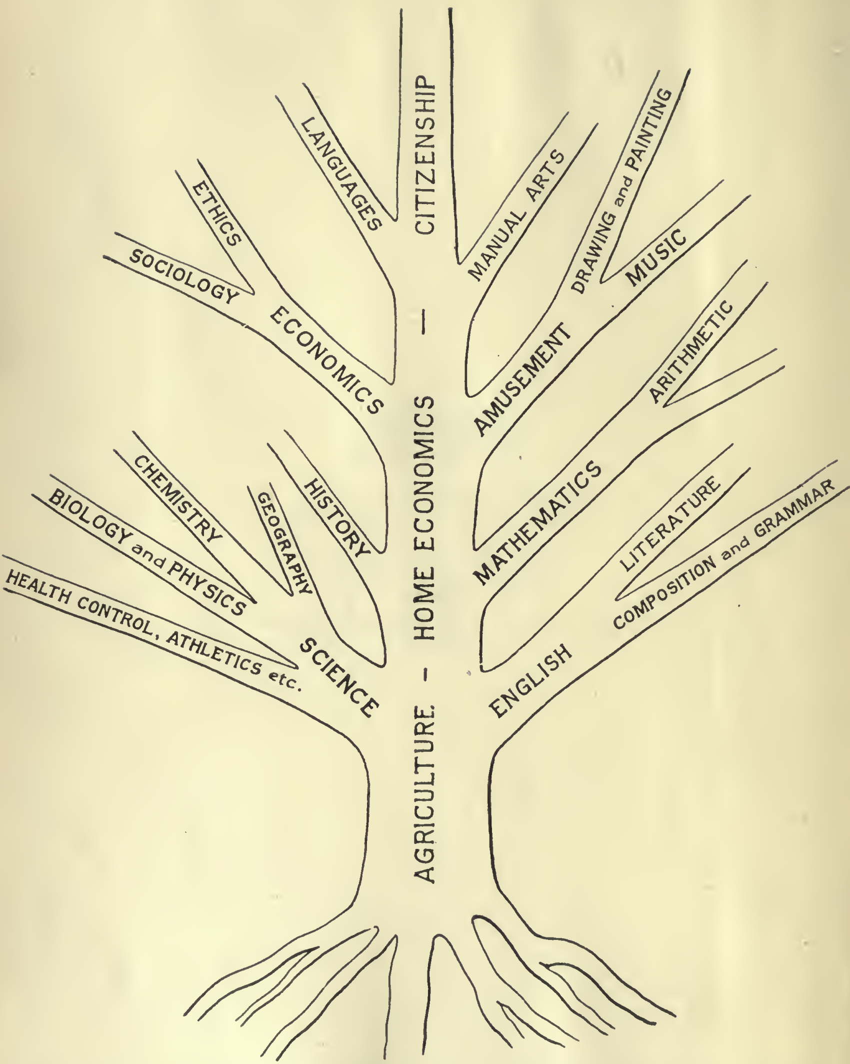

The basis for practical work in school that will function in the home and in the community.

THE PRINCIPLES OF AGRICULTURE

FOR HIGH SCHOOLS

BY

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PREFACE

THE chief motive of "The Principles of Agriculture" is to show how agricultural production may be increased. Agricultural production has not kept pace with the increase in population, and it behooves the American people to utilize those factors that will make agriculture more efficient. Greater production of agricultural products at a lower cost is constantly emphasized in this book.

The study of agriculture should carry over into actual farm operations. Every lesson and laboratory exercise is failing of its real value unless it creates an interest in and an appreciation of agriculture in practice, and makes our farm operations more productive.

The acreage yields in the United States are already increasing. This is shown in the following table:

INCREASE IN YIELDS OF CROPS IN U. S., 1917–1918

Compared with Previous Periods

	Increase in Total Yield			Average Yields at Periods		
	Average Yield 1912–1916	Average Yield 1917–1918	Percentage Increases	Decade 1907–1916	Average 1917–1918	Percentage Increases
Wheat	809,345,000	764,379,000	−5.5	14 7	14.6	− 0 06%
Corn	2,761,252,000	3,074,422,000	10.3	26.0	26.3	0.11
Oats	1,296,406,000	1,507,441,000	16.2	29.9	34.2	14 4
Barley	201,625,000	220,395,000	9.3	25 2	25.1	−0.04
Potatoes	361,753,000	416,721,000	15.2	95.4	97.5	2.2
Rye	44,547,000	68,416,000	53.4	16.3	17.2	5.5
Navy Bean	6,000,000	17,232,000	187.2	9.7	10.3	6.2

The above table clearly indicates that both the total yield and the acreage yield are increasing. "The Principles of Agriculture" as a text is useless unless it helps to increase yields and to decrease the cost of production.

The real agriculture is in the field, the garden, the orchard, and the barnyard. Soils, crops, and live stock constitute the subject matter of a practical course in agriculture. A first-hand study should be made of soils, plants, and animals. The laboratory method can hardly be overemphasized.

"The Principles of Agriculture" is a companion book to the Gehrs and James' Laboratory Manual entitled "One Hundred Exercises in Agriculture." The two are designed for a one-year course in high school agriculture. In some cases they may form the basis for one and one half to two years' work. Normal schools may find the books adaptable for their courses of high school rank.

The questions at the close of each chapter may be used for reviewing, the problems for pupils' reports, and the references for additional reading.

Schools may desire to do some club and project work. Where that is desired, write to your state leader of boys' and girls' club and project work for such material as is wanted. The author believes that a few projects or clubs started and completed have more value than several undertaken and none finished. The Indiana State Board of Education [1] says: "Rural schools will find that one project is sufficient for one year's work; and the high school teacher should limit the work to two projects each year;—the equivalent of one for each half year."

Grateful acknowledgments are due the following specialists for many valuable suggestions: R. A. Moore, Professor of Farm Crops, University of Wisconsin, for reading the section on Farm Crops; T. L. Lyon, Professor of Soils, Cornell University, for reading the section on Soils; Merritt W. Harper, Professor of Animal Husbandry, Cornell University, for reading the section on Farm Animals; C. H. Eckles, Professor of Dairy Husbandry,

[1] Educational Bulletin No. 27.

University of Missouri, for reading the chapter on Dairying; J. G. Halpin, Professor of Poultry Husbandry, University of Wisconsin, for reading the chapter on Poultry; J. C. Whitten, Professor of Pomology, University of California, for reading the section on Horticulture; and Professor D. H. Otis, Assistant Dean and Professor of Farm Management, University of Wisconsin, for reading the section on Farm Management.

Further credit is due Dr. W. S. Dearmont, President of the Cape Girardeau State Normal School; James C. Logan, Assistant Professor of Agriculture of the Cape Girardeau Normal School; and also Jeptha Riggs, Professor of English of the Cape Girardeau State Normal School; W. W. Parker, Associate Professor of English in the Warrensburg State Normal School; and Wm. McElresth, Manager of the Normal Farm, for many valuable suggestions given.

The Macmillan Publishing Company deserves special mention in these acknowledgments for many illustrations furnished and for sympathetic coöperation in the publication of the book.

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CAPE GIRARDEAU, MISSOURI
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THE PRINCIPLES OF AGRICULTURE

SECTION I. FARM CROPS

CHAPTER I

IMPROVEMENT OF PLANTS

Agricultural production not keeping pace with our population. — The population of the United States has constantly increased. Agricultural production has also increased but has not kept pace with the increase in population. Many people have moved to the cities, and the number of farmers in proportion to the rest of our population is less to-day than it has ever been. At the present time only one man in ten of our population is on a farm. That is, one man must produce enough food for eleven persons plus the food that is exported. In 1900 one man engaged in agriculture produced the food for 7.9 persons. In the early period of our history everybody lived upon farms. But because of lack of the use of productive plants and animals and machinery they often faced famine. If plants and animals to-day were no more efficient in production than they were in their native condition, they would not support our population.

Much has been done by the Agricultural Colleges, the United States Department of Agriculture and private citizens in improving plants. The scientific improvement of plants has been most rapid the last half century, and the knowledge of the adaptability of varieties to different conditions is recent. Great advancement has already been made. Many plants will produce eight

times as much as they did in the wild forms. Yet it is believed that there is chance for as much improvement as that which has already been wrought.

The open land of the United States is pretty well occupied and it is not our purpose to suggest an increase in acreage output, although that would help to increase our total food supply; but rather to present some of the lines along which plants are to be improved so that the average yield per acre will be larger. Some factors which will increase the efficiency of agricultural production are, the use of live stock and machinery, proper use of land, and farm management. These topics will receive attention in later chapters. In this chapter the improvement of plants alone will be discussed. Before we discuss the principal considerations of the chapter, two topics need a brief introductory treatment, namely: (1) Variation of plants; and (2) Selection as a basis for plant improvement.

1. *Variation in plants.*[1] — Plants of different species, types, and varieties of the same type vary in soil preferences, in the amount and distribution of rainfall needed for the best development, in the temperature required for optimum growth, and in the number of days required for complete maturity.

Different species of plants are suited to different sections of the country. Cotton is best adapted to the South, oats and potatoes to the North, and corn to the Central States.

On the other hand, *different types* of plants of the same *species* are adapted to different conditions. The Dent type of corn is grown almost wholly in the corn belt, but the Flint type is best adapted to the New England States. The common type of wheat is grown in the principal wheat producing states; but the Durum, or Macaroni type is grown in the Dakotas and on the western plains, because it is drought resistant.

[1] The laws of heredity underlying the transmission of characters were announced by Galton and Mendel. These will not be discussed in this book. But if it is desired to study the work of these two men material may be found in agricultural reference books.

The *varieties* of the same type of plants vary greatly. At Huntley, Montana,[1] 21 varieties of the Dent type of corn were grown side by side in rows 170 feet long. The best producing variety yielded 112 pounds of corn, and the lowest producing variety yielded 48 pounds of corn. The illustration shows how varieties may differ in producing ability.

Moreover, within the variety itself variations occur. Under the same conditions Southern Beauty, a variety of the Dent type, yielded in one plot 8.0 and in another 31.5 bushels of corn per acre, a difference of 23.5 bushels.[2] At the Iowa Station [3] 102 ears of the same variety varied in yield as follows:

Ear No. 75 yielded at the rate of 91 bushels per acre
Ear No. 93 yielded at the rate of 36 bushels per acre

Ear Number 75 yielded over two and one-half times as much as Ear Number 93. Thus within the same variety large variations occur.

So much for the variation of plants. The illustrations given indicate that plants of different species, types and varieties, and even plants within the variety itself, vary greatly. This variation of plants is the basis for selection, one key to the successful improvement of plants.

2. *Selection as a basis for plant improvement.* — Plants through variation are inclined to adapt themselves to the surroundings in which they grow. They become acclimated. They fit themselves to the soil, moisture, and temperature conditions of their surroundings. Special types, varieties, and strains have already been largely adjusted to local conditions. However, it is well known that many growers of plants are not using the varieties and strains best adapted to their locality.

Selecting from the best, the most adaptable, is the most important method at the disposal of the average farmer for the improvement of plants. Select the seed potatoes from the variety that

[1] Farmer's Bulletin No. 307. [2] Arkansas Station Bulletin No. 8.
[3] Bulletin No. 77.

is best adapted to your region, and take the seed from the hills that give the best yields. Take that seed corn that is best suited for the purpose for which it is to be used. Select that wheat which will yield the most good marketable wheat. Variation in plants is the largest factor in their improvement and every farmer can select the best.

Lines of plant improvement. — We have seen the principle on which plants may be improved. Let us now inquire how this principle applies to several important lines of plant improvement; such as: (1) Size; (2) Physical characteristics; (3) Prolificacy; (4) Flavor; (5) Color; (6) Chemical composition; (7) Resistance to drought; (8) Resistance to cold; (9) Immunity to disease; and (10) Length of cotton fiber. These are the fundamental considerations in the improvement of plants.

1. *Increasing size of plants.* — It is stated upon good authority that the Indians grew corn which had only 150 to 200 poorly developed kernels per ear. The largest ears they produced weighed about 2 ounces. To-day 120 average ears make a bushel of 56 pounds. That means that the average ear weighs about 8 ounces. There are ears that weigh 16 ounces and more. Corn has been increased in shelling capacity at least 800 per cent in the last 400 years.

Our domestic apples have been developed and improved from the wild crab apple. The number of apples to the cluster is fewer, but the fruit is probably 800 to 1000 per cent larger. It is possibly not desirable that the size of the largest apples now grown be increased, but it is desirable that the general average be increased.

All domestic plants have been wonderfully improved in size, and their yields are much greater than they were in the wild state. Further improvement is necessary if the human race is to be as well fed as it has been in the past.

2. *The physical characteristics of plants may be changed.* — Corn, wheat, oats, and some other plants have stems that may be changed in stiffness. Such an improvement prevents lodging. The fol-

lowing representative picture may illustrate the change in stiffness of straw which may be wrought in a short time by selection. Wheat, oats and other cereals that lodge seldom fill well, and are difficult to harvest.

The height of the corn stalk, the height at which the ear grows on the stalk and the diameter of the stalk have been changed

Courtesy Ohio Station.

Fig. 1. — Variation in stiffness of wheat straw due to three years of selection.

within reasonable limits according to the wishes of the grower. These stalk and ear characteristics determine largely how well the plant is to stand up. Our losses in corn yields are quite large because much of our corn blows down and decays before it is harvested.

Courtesy of Ill. Station.

FIG. 2. — The corn shown in the above figure descended from the same ear. The variation in height of ears was secured by several years of selection.

3. *Making plants more prolific.* — Prolificacy is an important matter in the improvement of plants. Every one knows that some corn stems bear two good ears of corn, each ear having about 1000 good kernels. Another stalk just by the side of it, growing under the same conditions, may have only 400 to 500 poor kernels. The difference in yield is not due to different conditions of culture or rainfall, but to prolificacy. (See picture, page 66.)

Varieties, too, vary greatly in productiveness. The following quotation from the Purdue Experiment Station[1] is applicable at this point: "The best half dozen varieties of wheat averaged over 12 bushels per acre above the poorest half dozen. And the difference between the best and the poorest was 18.6 bushels per acre." Figure 3 illustrates what may be done by constantly selecting the most prolific. The large head will yield from 10 to 20 per cent more wheat than the small one.

Fig. 3. — The result of four years' selection to increase prolificacy. The large head will yield 10 to 20 per cent more wheat than the smaller one.

4. *Flavor may be improved.* — Flavor is an important consideration in the improvement of plants, and is one primal thing in crops which may be improved. The wild crab apple is the progenitor of all domestic varieties of apples. The wild crab has a sour, acid, sharp flavor. But from this poorly flavored crab apple all our domestic varieties have sprung, possessing flavors suited to the tastes of every person.

The wild grape had in it all the possibilities that we find to-day in all of our domestic varieties. It had, however, a sour, acrid flavor. But through selection the excellent Concord, the White Niagara and 150 other varieties have been produced. All of them vary slightly in flavor as well as in other qualities. Every plant of field, orchard and

[1] Bulletin No. 49.

garden must be constantly selected and improved in order that a desirable flavor may be maintained.

5. *Color in plants.* — The improvement and maintenance of color in plant products is an important consideration in plant production. Thus Reid's Yellow Dent corn is a lemon yellow; Cartner, a golden yellow; and all white varieties, pure white or creamy white. Different varieties of oats have each a certain standard color, toward which the plant improver must constantly breed. The floriculturist devotes much time to selecting and improving his flowers in order that they may appeal to the æsthetic tastes of his customers. The fruit grower likewise knows the value of color, for it is well known that red apples and yellow apples sell more readily and at a higher price than apples having a green color. The black varieties of grapes sell better than those that are white. So it is throughout the entire plant kingdom; the green holly, mistletoe, cedar and fir would be worthless at Christmas time were it not for their color.

6. *Improving the chemical composition.* — It is well known that the chemical composition of plants may be changed. Often the value of changing the chemical composition is inestimable. Two illustrations — one with beets, the other with corn — will be given to indicate what has been done in changing the chemical composition.

(1) The chemical composition of the sugar beet was first investigated by Louis Vilmorin about 1830 to 1840. He tested beets by placing them in a brine solution. The solution was made so dense that the great majority of the beets would float, and the few that sank presumably had a higher sugar content. About 1851, chemical analysis was used to determine the sugar content of beets. At that time beets tested from 7 to 14 per cent sugar. In a few generations, through selection, beets were secured that tested as high as 21 per cent sugar. The work of improvement through selection has constantly continued, but the highest sugar content found in beets up to the present time is 26 per cent. The average sugar content of beets ranges from 14 to 18 per cent,

although entire fields have been known to yield 22 per cent sugar.

(2) The chemical composition of corn may be changed to some extent. Thus at the Illinois Station[1] the following change in protein content was secured in 12 years by starting in 1906 with seed coming from the same ear.

CHANGE IN PROTEIN IN CORN DUE TO VARIATION AND SELECTION

	High Protein Plot	Low Protein Plot	Difference in Crops Harvested
	Average Per Cent of Crop Harvested	Average Per Cent of Crop Harvested	
1896	10.92	10.92	0.00
1897	11.10	10.55	0.45
1898	10.05	10.55	0.50
1899	11.46	9.86	1.60
1900	13.32	9.34	3.98
1901	14.12	10.04	4.08
1902	12.34	8.22	4.12
1903	13.04	8.62	4.42
1904	15.03	9.27	5.76
1905	14.72	8.57	6.15
1906	14.26	8.64	5.62
1907	13.89	7.32	6.57

By selecting the best the amount of protein was increased in the 12 years about 3 per cent; and by selecting the poorest the amount of protein was reduced in the same time about 3.6 per cent.

The oil content of corn may likewise be changed through selection. According to the publication above quoted the oil content was increased from 4.7 to 7 per cent for the high oil plot, and decreased to 2.59 per cent in the low oil plot. Since from 80 to 85 per cent of all the fat is in the germ, growing corn with a larger germ increased the proportionate part of oil. Professor Hopkins[2] found that if a higher starch content in corn is desired, it may be secured by breeding for low protein and oil.

[1] Missouri State Board of Agriculture Report, 1909.

[2] Illinois Bulletin No. 87.

Whether it is desirable to have corn with a high protein and oil content or with a high starch content depends on the use to which it is to be put. A corn rich in protein is preferred for horses doing hard muscular work, particularly in the corn belt, where other feeds furnish the necessary carbohydrates. In the South, however, where other feeds, such as cowpea hay and cotton-seed products, are lacking in the carbohydrates, a corn with a higher starch content is preferred. Corn for the manufacture of starch or glucose should, of course, be rich in starch.

7. *Drought resistant plants.* — Since a large portion of the arid section of the United States can never be irrigated, it behooves us to produce such plants as are adaptable to those sections; that is, are drought resistant. Some of the plants which are drought resistant are the sorghums, kafir corn, milo maize, feterito, dura corn, and durum wheat; and to a less degree, alfalfa, cowpeas, and soy beans.

But even among the different types of farm crops other than those named in the above paragraph, there are varieties which have been and are being developed and improved so that they are now drought resistant. Only one illustration will be given, but it is a representative one. What is true of corn is also true of other species of plants.

"The precipitation, elevation, and soil conditions vary so much in different sections of Kansas that the varieties of corn which grow best in one locality are frequently very poorly adapted to others. In eastern Kansas the annual rainfall averages 35 inches or more. In this area fairly large varieties usually produce the largest yields. In western Kansas the annual rainfall is less than 20 inches, and the elevation is from 1500 to 2500 feet above that of eastern Kansas. If the large, late-maturing varieties of eastern Kansas are grown in this area, they will invariably be injured by drouth, hot winds, or early frosts. They may produce fodder, but they will not produce grain. On the other hand, if the small early-maturing varieties usually grown in western Kansas are grown in eastern Kansas, they will ripen so early that they

will not derive any advantage from the longer season and greater supply of moisture, and will consequently produce a low yield as compared with the adapted varieties."[1]

8. *Increasing resistance to cold.* — Some plants need to be improved in their capacity to resist cold. It is true that natural selection tends to eliminate the weak plants; but by additional

Courtesy Ohio Station.

FIG. 4. — Variation in winter resistance.

artificial selection, we may increase the yields, and reduce the cost of production by selecting winter resisting varieties. The above picture illustrates winter resistance of wheat.

The above figure shows a wide variation in hardiness and resistance to winter conditions. The bulletin says[2] "the rows seemed

[1] Kansas Station Bulletin No. 205.

[2] Ohio Station Bulletin No. 298.

equally vigorous during the fall, but one of them was nearly destroyed during the winter."

9. *Resistance to disease.* — Disease resistant plants have been developed. The same plant often shows wide variations in its resisting power. Thus[1] some oats were 90 per cent free from rusts, and others growing on the same soil were only 75 per cent rust free. Wheat likewise varies in its immunity from rust. Plants which are largely immune from rusts help in increasing yields.

Wilt is one of the most serious diseases of cotton. Straws of cotton have been developed which are largely resistant to the disease. Several of the Egyptian varieties and the Jackson Limbless are resistant to the disease to a large extent. Wilt-resistant varieties are secured by selecting the seed from those plants which have a high immunity to the disease.

10. *Improvement of cotton.* — Three-fourths of the cotton of the world is grown in the United States. It is here that the greatest improvement has taken place, and yet the average production is only 190 pounds of lint per acre. It is believed that the production could be doubled by proper seed selection and good methods of cultivation.

The length of cotton fibers in short-staple cotton is from $\frac{3}{4}$ to 1 inch; while in the long-staple cotton the length ranges from 1 to $1\frac{1}{2}$ inches. Length of fiber and increase of yield are the two important things to consider in cotton improvement.

Summary. — The improvement of plants is one of the important factors in making our crops more productive. It is because of this fact that the United States Department of Agriculture, the state Agricultural Colleges and many private citizens are devoting much time, energy and money to this one phase of plant production. Some of the fundamental considerations in the improvement of plants are: (1) Increasing their size; (2) Improving their physical characteristics; (3) Making them more prolific; (4) Improving the flavor of some; (5) Maintaining and improv-

[1] Bureau of Plant Industry. Circular No. 20.

ing the color; (6) Changing the chemical composition; (7) Making some plants more drought-resistant; (8) Increasing the resistance to cold; (9) Making plants immune from diseases; and (10) Improving the cotton fiber in yield and length of staple.

Although our domestic plants are from 400 to 1000 per cent more productive than the wild forms were, yet it is believed that the opportunities for further improvement in productiveness are as great as the improvements that have already been made. He who positively improves our plants in any of the characteristics above named is a benefactor to the entire world.

QUESTIONS

1. What are the lines along which plants are to be further improved?

2. How would you increase the size of the ear of corn? How would you increase the number of rows on the ear?

3. How would you develop corn stalks that would be more wind resistant?

4. What is the meaning of the term *prolificacy?* How would you secure prolificacy in corn? Wheat? Oats?

5. Describe the color of four varieties of apples. Why is color so important?

6. How much has the sugar beet been improved?

7. Are the plants of your state adapted to the moisture condition of the region? Name some plants, growing in your locality, which are more drought resistant than others.

8. What is the average acreage yield of corn, wheat, oats and cotton of your state? Is it a good average? Why?

PROBLEMS

1. A plot of corn 16 hills square planted 42 inches each way equals $\frac{1}{12}$ acre. Count the number of barren stalks and estimate the percentage of loss per acre due to barren stalks. For a given field.
2. Suggest several characteristics in which the corn of your locality might be improved.

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U. S. Yearbooks of Agriculture. 1899, 1902, 1907, 1911.
Bailey, Cyclopedia, Vol. II, pp. 53–69.
Davenport, Domesticated Animals and Plants.
Hunt, Cereals in America.
Bulletins.

CHAPTER II

WHEAT[1]

History of wheat. — The exact location and time of the origin of wheat is unknown. In prehistoric times the peoples of western Asia, Europe, and northern Africa used wheat. It is mentioned in the first books of the Bible and in other early writings.

In a later period of history the Greeks, the Romans, and the medieval nations became the medium through which wheat was disseminated. Then the modern nations, England, France, Spain, Portugal, and America and all the nations of the world, became the guardians of wheat production. Wheat was first grown in America about 1602. To-day all the civilized nations of the world grow wheat. It is a mark of civilization for nations to produce wheat and consume the products which can be made of it. Only about half of the peoples of the world eat light bread. The use of light bread increases as civilization advances.

Importance of wheat. — Wheat is the most important plant grown in the world, though in actual tonnage it is exceeded by both corn and potatoes.

WORLD'S CROPS OF THE MOST IMPORTANT HUMAN FOOD PLANTS — 1906–1911[2]

VALUE	CROP	MILLIONS OF TONS
$ 187,000,000	Potatoes	156
1,431,000,000	Corn	113
590,000,000	Wheat	107
367,000,000	Oats	67
207,000,000	Rice	67
138,000,000	Rye	46
92,000,000	Barley	33

[1] For suggestive laboratory work on wheat turn to the Gehrs and James Laboratory manual entitled "One Hundred Exercises in Agriculture."

[2] Quoted from Montgomery's "Productive Farm Crops."

The world's wheat crop (1906–1910) ranked third in production and in value. But as a human food it ranks first.

The following data show where the wheat of the world is produced.[1] Europe and North America produce almost 80 per cent of the wheat of the world. The countries producing the greatest amount of wheat are in the order of production the United States, Russia, France, India, Austria and Italy.

WHEAT PRODUCTION IN BUSHELS, BY GRAND DIVISIONS

	Bushels	Per cent (0%–60%)
Europe	1,951,000,000	51.4%
North America	1,046,000,000	27.6%
Asia	444,000,000	11.7%
South America	183,000,000	4.8%
Oceania	86,000,000	2.2%
Africa	80,000,000	2.1%
World	3,790,000,000	

Wheat is a very important crop in the United States. In money value it stands next to corn, and in bushels produced it is exceeded only by corn and oats. The largest yield of wheat was in 1915 when 1,011,505,000 bushels were produced.

THE LEADING WHEAT STATES, 1914–1918 INCLUSIVE

United States	816,063,000	
Kansas	105,093,000	12.8%
North Dakota	84,000,000	10.2%
Minnesota	54,130,000	6.6%
Nebraska	53,500,000	6.5%
South Dakota	47,580,000	5.8%
Illinois	39,185,000	4.9%
Washington	39,000,000	4.8%
Indiana	38,500,000	4.7%
Oklahoma	36,316,000	4.4%
Ohio	35,175,000	4.3%
Missouri	33,540,000	4.1%
Montana	26,415,000	3.2%

[1] U. S. Yearbooks of Agriculture. 1911–1915 inclusive.

The 1918 yield was 918,920,000 bushels.[1] The Wheat states are shown in the preceding graph, and the following map.[1]

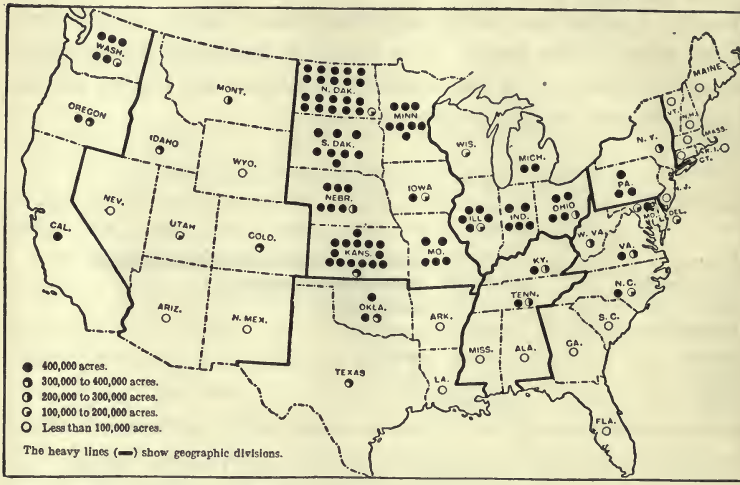


FIG. 5. — The above map shows the distribution of acreage of wheat production of the United States.

Wheat districts of the United States. — Wheats are classified according to the time of sowing and the nature of the kernel, — its color and hardness, due to the gluten content. On this basis there are in the United States seven well-defined wheat districts. See the map on page 17.

1. The semihard-winter-wheat district includes the states of Illinois, Iowa, Missouri, Indiana, Ohio, Pennsylvania, Kentucky and the eastern half of Kansas, Oklahoma and Nebraska. The wheat grown is from soft to semihard, and is sown in the fall.

2. The hard-winter-wheat district includes the states of Kansas, Nebraska and Montana, and extends into Missouri and Oklahoma. Hard winter wheat produces excellent light bread. The kernels contain a great proportion of protein (gluten) and for that

[1] U. S. Yearbook of Agriculture. 1918.

reason are hard; when a cross section of the kernel is examined, it has a grayish amber color.

3. The hard-spring-wheat district, which produces about one-third of the wheat produced in the United States, comprises the states of Minnesota, North and South Dakota, and parts of Wisconsin, Iowa, Nebraska, Montana and Colorado. The largest flouring mills are found in this section.

4. The soft-wheat district includes the states of Washington, Oregon and California. The kernels of wheat grown in this

FIG. 6. — The principal wheat districts of the United States.

section are white and very soft. They are relatively lower in protein content and higher in starches. Pastries, crackers and biscuits are made of soft wheat flour.

5. The Atlantic Coast wheat district produces a soft wheat, and while it does not export much wheat, it produces enough to supply local demands.

6. The Durum-wheat district overlaps somewhat the hard-winter, and hard-spring-wheat districts. It comprises the states

of Nebraska, Kansas, Montana, Colorado and the Dakotas. Durum wheats are adapted to rather dry, arid regions, and are therefore grown where other types would not thrive. When the hard winter and hard spring types can be grown, they are preferred.

Economical aspects of wheat production. — The cost of acreage wheat production varies according to the kind of land cultivated, the method of culture employed, the kind of implements used, and the number of horses driven by one man. The cost of bushel production of wheat depends principally upon the acreage yield. To illustrate the preceding statements, it costs less per bushel, when 30 bushels to the acre are produced than when 10 bushels are produced. It costs less to plow and produce an acre of wheat on oat land than it does to plow up an alfalfa soil and get it in shape for wheat production. It costs more to sow wheat and harvest it with the implements used by our forefathers than it does with modern machinery. It costs more to produce wheat when a man is using only one horse, than when he is using three or four.

The acreage cost of wheat production in various sections of the United States has been estimated by the U. S. Department of Agriculture to be as follows:[1]

Cost to Produce an Acre of Wheat

1. Rental on land or interest on source	$ 3.30
2. Preparation of soil	2.11
3. Seed	1.42
4. Fertilizer	.58
5. Sowing	.46
6. Harvesting	1.33
7. Threshing and preparing for market	1.48
8. Other items	.48
Total	$11.16

In the above calculation, the amount and value of the elements taken out of the soil were not included. These should be con-

[1] Crop Reporter. 1911.

sidered. The number of pounds of nitrogen, phosphorus, and potash taken out per each 1000 (16 bushels and 40 pounds) pounds of wheat removed is 19.8, 8.6 and 5.3 pounds respectively. These elements are worth ordinarily about 15, 6 and 6 cents respectively. Then the fertility removed is as follows:

19.8×15	$2.97
8.6×6	.50
5.3×6	.31
Total	$3.79

Since the cost of production is $11.16 and the fertility removed is $3.79, the total cost of acreage production for 1911 was $14.95. The cost of wheat production is, of course, somewhat more at the present time.

Two stations give these figures on the average cost of wheat production, exclusive of value of fertility removed:

Cost of Acreage Production

Minn. Bul. No. 145	Mo. Bul. No. 125
$10.78	$12.30

As horsepower, implements, man labor, fertilizers, threshing, seed, etc., increase in price (not necessarily in value) the cost of wheat production increases.

Cost and Acreage Yield of Wheat in Different Countries

	Cost of Bushel Production	Average Acreage Yield
United Kingdom . .	45 cents not including land rent	33.4
Germany	92 cents not including land rent	30.7
France	58 cents not including land rent	20.1
Hungary	55 cents not including land rent	18.1
United States . . .	85 cents not including land rent	15.0
European Russia . .	45 cents not including land rent	11.0

European countries ordinarily produce more wheat per acre than we produce in the United States, but one man in the United States produces about four times as many bushels as one farmer does in Europe. The cost of bushel production and acreage yield of wheat for the leading wheat producing nations is shown in the preceding table.[1]

It will be noted that the yield in the United States is only 15 bushels per acre. How to increase the acreage yield is discussed in the following paragraphs.

Factors that help to increase wheat yields. — There are a few factors which will almost double the acreage wheat yields. These factors are:

1. Early plowing.
2. The nature and condition of the seed bed.
3. Rotation of crops.
4. Drilling the wheat.
5. The time of sowing.
6. Plump and heavy grains for seed.
7. Prolific and adaptable varieties.
8. Proper rate of seeding.
9. Barnyard manures.
10. Commercial fertilizers.
11. Combating of diseases and insects.
12. The scientific method of harvesting.

1. *Early plowing produces more wheat.* — Early plowing is one of the most important factors in securing more wheat per acre. This has been verified by the Michigan, North Dakota, Kansas, Oklahoma and other experiment stations. Every farmer knows that early plowed soils produce more wheat than late plowed soils. The following representative data taken from the Kansas Station[2] show the relation of early plowing to wheat production. According to the data, the land plowed July 15 yielded 35 bushels, whereas the land plowed September 15 yielded 17.5 bushels per acre, — just half as much. All the land was plowed

[1] U. S. Yearbooks of Agriculture. 1905–1914.

[2] Bulletin No. 185.

7 inches deep. At the Oklahoma Station[1] time of plowing had the following effect upon wheat yields:

Soil Plowed	Yield, Bushels Acre
July 19	31.3
August 15	23.5
September 11	15.3

Land plowed July 19 produced more than twice as much wheat per acre as the land plowed September 15. Early time of plowing alone increases the wheat yield 50 to 100 per cent an acre.

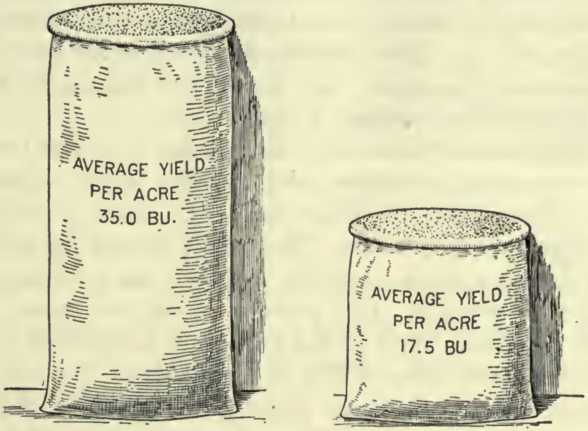


Fig. 7. — The effect of time of plowing upon economic wheat production.

A soil that is prepared early conserves the soil moisture much better than a soil that is prepared late. At the Kansas Station[2] as a four years' average the following conditions obtained:

	Available Moisture Contained at Seeding Time	Grain, Bushels	Straw, Pounds
Late fall plowed	2.7%	5.9	1015
Early fall plowed	4.2	11.1	1978
Fallowed	8.8	21.2	3531

[1] Bulletin No. 47.

[2] Bulletin No. 206.

The precipitation during the growing period of the crop was 12.32 inches. It may be observed from the above table that the grain and straw yield was almost in direct proportion to the amount of available moisture present at seeding time.

No erroneous conclusions should be drawn from the above experiment, but a few suggestions may be in order: (1) Throughout the wheat belt, the amount of moisture at seeding time is often very limited, and for that reason the soil should be prepared so that a maximum amount of the rainfall may be conserved. (2) Any seed bed that contains a fair amount of available moisture will produce such a stand of wheat that dangers from winter killing are minimized. (3) Later sowing may be employed when plenty of soil moisture is present; and thereby the Hessian fly may be almost wholly, if not entirely, avoided.

2. *The nature and condition of the seed bed is another important factor in securing maximum wheat yields.* Wheat demands a mellow, well-prepared, compact seed bed. Early plowing may be at a depth of 5 to 7 inches. Thoroughly disking the soil before plowing insures a uniform, mellow seed bed and is recommended as good farm practice. Late plowing should not exceed, under ordinary conditions, three to five inches, for late-plowed soil cannot be compacted properly if it is plowed deep. To sow wheat on a loose, cloddy soil means wheat production at a high cost. The seed bed for wheat should be like the garden seed bed. If turnips will grow, wheat will also grow.

3. *Rotation of crops* bears an important relation to wheat yields. At the Ohio Station[1] the following results were secured:

	Yield per Acre		Gain or Loss	Twenty Years' Average Bushels
	First Decade	Second Decade		
Continuous — Wheat	9.24	5.79	−37.3%	7.52
Rotation — Corn, Wheat, and Clover	9.92	12.78	+28.8%	11.35

[1] Bulletin No. 298.

All plots in the above table were grown without manure or fertilizer for 20 years. The experiment shows that continuous culture of wheat will result in decreased yields; and that by practicing rotation the yields may be not only maintained, but actually increased.

4. *Drilling wheat* is an important factor in increasing wheat yields. At the Ohio Station[1] in a 5-year test, drilled wheat averaged 28.7 bushels per acre, whereas broadcasted wheat yielded 24.9 bushels. The Kentucky Station in three years' trial found a gain of 4 bushels in favor of drilling; Indiana in 4 years found 8 bushels gain; and Ohio reports 9 bushels. At the Nebraska Station[2] the following results were secured:

Year	Broadcasted	Drilled	Increase from Drilling Bushels
1908	20.0	29.6	9.6
1909	17.0	27.2	10.2
1912	5.0	5.9	0.9
Average			6.9

These additional yields due to drilling are worthy of the consideration of every producer of wheat. Drilling wheat has the following advantages:

(1) The seed wheat is sown at an even depth.

(2) The seed wheat is uniformly distributed in the soil.

(3) The furrows and ridges catch and hold the winter snows and prevent freezing.

Depth of drilling depends upon the condition of the soil, as regards moisture and tilth. Wheat may be drilled from 1 to 3 inches deep, according to the season. In a 5-year test the average results of different depths of drilling at the Ohio Station[3] were

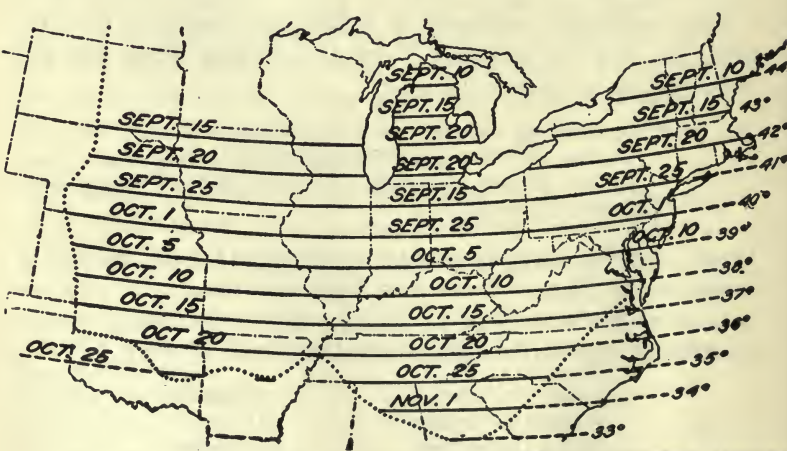
Drilled 1 inch deep	28.7 bushels
Drilled 2 inches deep	28.7 bushels
Drilled 3 inches deep	28.5 bushels

[1] Bulletin No. 298. [2] Bulletin No. 135. [3] Bulletin No. 298.

5. *Time of sowing* is an important factor in securing a good yield. Where the soil has been well prepared, wheat may be

FIG. 8. — A wheat drill properly used helps to increase wheat yields, and reduce the cost.

sown on or after the fly-free dates, as shown by the following map, furnished by the United States Department of Agriculture:



Courtesy U. S. Department of Agriculture.

FIG. 9. — Fly-free dates for seeding wheat.

While no definite date can be stated as to the best time when wheat is to be sown, it may be stated that an exceedingly heavy growth in the fall is sometimes more objectionable than a normal growth, for a heavy growth takes an excess of moisture from the soil. Spring wheat should be sown as soon as possible. The early wheat sown in the cool spring weather stools better, and evades the ravages of disease and insects. It is for this reason that for spring sowing early seeding is recommended.

6. *Plump, heavy grains* aid in getting larger yields, and this factor should receive the most careful attention of every farmer. The method practiced by the specialist in plant breeding cannot be followed by the farmer; but he can use the fanning mill, which will eliminate the small shriveled grains. That it pays to carefully grade the seed wheat is shown by the data furnished by the following experiment station records:

COMPARISON OF HEAVY AND LIGHT SEED

	Yields in Bushels per Acre		Difference in Favor of Heavy Seed
	Heavy Seed	Light Seed	
Minnesota [1]	29.4 bu.	24.8 bu.	4.6 bu.
Kansas [3]	27.1 bu.	25.2 bu.	1.9 bu.
Nebraska [2]	27.9 bu.	22.8 bu.	5.1 bu.
Ontario [3]	38.6 bu.	33.7 bu.	4.9 bu.
Averages	30.7 bu.	26.6 bu.	4.1 bu.

COMPARISON OF LARGE AND SMALL SEEDS

	Yields in Bushels per Acre		Difference in Favor of Large Seed
	Large Seed	Small Seed	
Ohio	16.3 bu.	16.3 bu.	0.0 bu.
Indiana	30.5 bu.	27.9 bu.	2.6 bu.
Ontario	46.9 bu.	40.4 bu.	6.5 bu.
Tennessee	28.6 bu.	23.4 bu.	5.2 bu.
Averages	30.6 bu.	27.0 bu.	3.6 bu.

[1] Minnesota Station Bulletin 115. [2] Nebraska Station Bulletin 72.
[3] Bureau of Plant Industry.

Each of the above tables shows important average gains in favor of large, heavy seed wheat. The gain from careful grading is due to the fact that the smaller and lighter kernels are not well matured, and consequently are less vigorous in producing thrifty plants.

Courtesy Indiana Station.

FIG. 10. — The fanning mill is a simple and effective means of eliminating poor seed wheat.

7. *Some wheat varieties are more prolific than others.* — Plants, like animals, vary greatly in their powers of multiplication. Some increase rapidly, some slowly, and some not at all. At the Illinois Station[1] in a series of 63 tests covering a period of 12 years, Turkey Red yielded an average of 42.4 bushels per acre; while Miracle in 8 tests in one year produced only 15 bushels per acre.

[1] Bulletin No. 201.

At the Indiana Station[1] the following results covering the years 1901–1911 inclusive, were obtained:

Some of the Highest and Lowest Yielding Varieties of Winter Wheat Tested at Purdue University

Highest Yielders	Bushels per Acre	Lowest Yielders	Bushels per Acre
Rudy	34.0	Diamond Grit	18.5
Mealy	31.7	Early Arcadian	20.0
Tennessee Fultz	35.1	Dunlap	21.7
Golden Coin	33.6	Winter Chief	23.1
Winter King	33.3	Hedge's Prolific	23.5
Grains O'Gold	32.8	Queen of New York	24.7
Average	31.8	Average	21.9

To quote the Bulletin, "The best half dozen varieties have averaged over 12 bushels per acre above the poorest half dozen, and the difference between the best and poorest is 18.6 bushels per acre."

The varieties recommended by the Chief of Agronomists of the several experiment stations is shown in the map on the next page.

8. *Rate of seeding.* — The rate of seeding varies a great deal and depends upon the time of seeding, the kind of season, the condition of the seed bed, the size of the kernels and the method of seeding. Less seed is required if sown early, if the soil is rich and the season is good. A cool, moist season causes wheat to tiller or stool. This is one of the greatest factors influencing the amount of seed necessary. There may be almost twice as many kernels in a bushel when the grains are small, than if they are large. The experiment stations of Kansas, Illinois, Indiana, Ohio, Kentucky, Wisconsin, Missouri and Oklahoma for periods ranging from 5 to 15 years have found that the greatest yields are secured when from 6 to 8 pecks of seed wheat are sown. The yield is not in proportion to the seed sown. There are so many

[1] Circular No. 23.

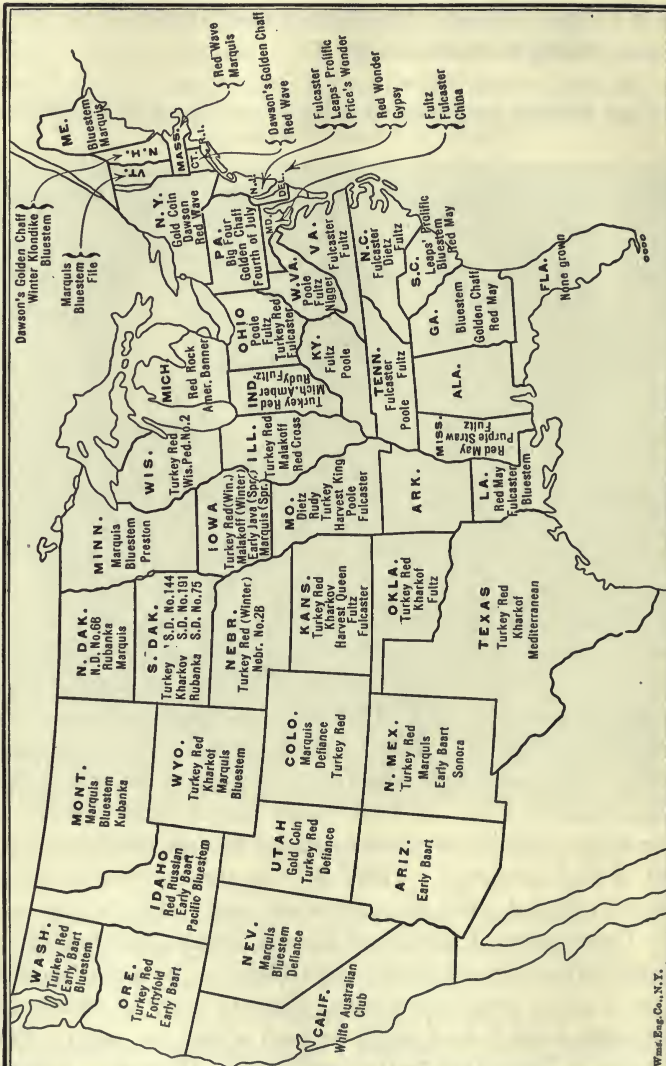


FIG. 11. — Some of the varieties of wheat recommended by your State Experiment Station for your state.

factors that influence the stand of wheat that no one can determine in advance what it will be. The wheat plant is very adaptable and responds readily to the proper conditions.

9. *Barnyard manures* aid in increasing wheat yields. The chapter on manures is found on page 446, but the relation of manure to wheat production will be briefly discussed here. At the Rothamsted Station, England, two similar plots of soils were kept in wheat for 40 consecutive years. One plot was sown to wheat without manuring or giving any other kind of treatment. The other plot was manured annually at the rate of 14 tons to the acre. The seed, culture and harvesting were similar in each case. The results are given in five eight-year periods:

THE VALUE OF BARNYARD MANURES IN WHEAT PRODUCTION

	Barnyard Manure Added 14 Tons Yearly	No Manure	Gain in Favor of Manure
First 8 years	34 bu.	16 bu.	18 bu.
Second 8 years	35 bu.	13 bu.	22 bu.
Third 8 years	35 bu.	12 bu.	23 bu.
Fourth 8 years	28 bu.	10 bu.	18 bu.
Fifth 8 years	29 bu.	12 bu.	27 bu.
Average 40 years	34 bu.	13 bu.	21 bu.

It will be evident from the above table that barnyard manure may be made an important factor in wheat production, as in the above forty-year test an average gain of 21 bushels annually was due to barnyard manure. The following data[1] give evidence of the value of barnyard manure:

AVERAGE YIELDS — 19 YEARS — 1897–1915

	Grain	Straw
Average with manure	21.37 bu.	2395 lb.
No treatment	11.76 bu.	1395 lb.
Excess	9.61 bu.	1000 lb.

[1] Bulletin No. 305. Ohio Station.

At the Purdue Experiment Station[1] it has been found that light applications of manure yielded almost as good returns as heavy applications, and the production secured was at less cost. The average value of increase produced by the manure per crop and per ton of manure for 23 years (1890–1912) at the Purdue Experiment Station follows (wheat valued at 80¢ per bushel):

LIGHT APPLICATIONS OF MANURE VS. HEAVY APPLICATIONS

	Average Fertilization in Tons per Rotation		Value of Increase	
	Heavy	Light	Heavy	Light
Wheat, in corn, oats, clover rotation	14.24	8.8	$ 5.83	$4.52
Wheat, in corn, oats rotation . .	14.24	9.1	7.33	5.53
Wheat, in wheat, corn rotation . .	10.94	6.72	11.45	9.33
Wheat, continuously	4.35	2.72	1.42	1.93

In the words of the bulletin, "The data of the table emphasize one point very strongly and consistently that the lighter applications of manure always give a greater return per ton than the heavy applications. This point is also shown very clearly by results obtained by the Ohio Station. On an average for 20 years $2\frac{1}{2}$ tons applied per annum in continuous wheat culture have given an increase of $1.81 per ton, while a five ton application has given an increase of $2.07." Therefore, in manuring wheat ground better results may be secured by adding light applications, and extending the manure over more territory, than by heavy applications and restricting the area over which the manure is applied.

10. *Commercial fertilizers* help in increasing wheat yields. The College of Agriculture at Columbia, Missouri, has for a period of 12 years conducted experiments at 30 different places in the state trying to determine the value of fertilizers in increasing wheat yields. To quote:[2] "Various seasons and soils have been

[1] Circular No. 49. [2] Missouri Station Circular No. 9.

included in these tests, but almost without exception profitable results have been secured from the use of phosphate fertilizers on wheat. Out of 97 tests covering the period 1905–1917 only twelve have failed to show an increase in the wheat crop where bone meal was used. The average yield including all the 97 tests has been 4.5 bushels greater with bone meal than without it. There has also been an average increase in the straw yield of 600 pounds per acre. It has been the practice to use 150 pounds of steamed bone meal to the acre. The bone meal is worth about $2.10 at usual prices, and $2.50 to $2.65 at abnormal prices. Will 4.5 bushels of wheat and 600 pounds of straw pay for this expenditure?" It will, ordinarily.

At the Rothamsted Station, England, the continued use of abundant fertilizer on wheat during a period of 50 years (1852–1902) yielded returns as follows:

Continuous Wheat, Rothamsted, England, 50 Years

Treatment	Average Yield per Acre
Untreated	13.1 bu.
Minerals alone added	14.9 bu.
Nitrogen alone added	20.7 bu.
Heavy application complete fertilizer	37.1 bu.
Barnyard manure added	35.7 bu.

This experiment shows that the fear often manifested by farmers that fertilizers may injure the soil is fortunately not true. As a matter of fact, reduced fertility is not due to the use of commercial fertilizers, but usually to poor methods of soil management. A complete fertilizer contains these ingredients — nitrogen, phosphoric acid and potash. A 2-8-4 fertilizer has been found to be a fairly good fertilizer for wheat production under average conditions.

11. *Combating the enemies* of wheat is a large and important factor in its production. There are two classes of enemies of

wheat, fungi and insects. Of the fungous diseases, there are three that are important; namely, the loose smut, the stinking smut and the rusts. *Loose smut* attacks the wheat head and changes the entire head into a black, powdery mass. It is not very destructive. *Stinking smut*, according to the U. S. Department of Agriculture, causes an annual loss of about $11,000,000 to our wheat crop. It attacks the kernels only and is therefore often overlooked; but at threshing time the black, dusty, ill-smelling spores are indicative of its presence. When the kernels

FIG. 12. — Treating seed wheat for stinking smut with formalin.

are cut, the endosperm, instead of being white, is black, containing the stinking smut spores. Stinking smut annoys the miller a great deal, for one smutty grain blackens a great deal of flour. Stinking smut may be controlled by the use of the formalin treatment for the seed wheat. Spread the seed wheat thinly over a floor; then to a pint of 40 per cent formalin add 36 gallons of water and with this solution moisten the seed wheat thoroughly. The above amount of formalin will treat about 45 bushels of seed

wheat. Oats may be treated in the same way. As soon as the seed is well moistened, cover it with a canvas for six or ten hours. This will keep the fumes of formalin around the kernels. Then spread the seed out to dry. When dry it is ready to sow. Good drills will sow the seed when quite damp, but they must be set to sow more seed per acre than if sowing dry seed.

Rusts attack both stem and leaves, and do considerable damage in some seasons. There is no effective remedy for the control of rusts, except to grow rust resisting varieties of wheat.

The two chief insect enemies of wheat are the Hessian fly and the chinch bug. *The Hessian fly* causes a loss of about 4,000,000 bushels annually. The larva of the Hessian fly looks like a flax seed and it is during this stage that the Hessian fly does its damage to the wheat plant. These larvæ live just between the leaf sheath and the wheat stem at the nodes and cause an enlargement. The wheat plant usually breaks down a week or two before maturity. Cir. 29, Missouri Station, gives the following four points as a basis for control: (1) Destroy the natural home of the fly by plowing early and deep; (2) Keep down all volunteer wheat between plowing time and seeding date; (3) Delay wheat seeding until after the fly-free date; and (4) Coöperate with neighbors in practicing these three measures.

The chinch bug is the other important insect enemy of wheat. Chinch bugs hibernate in fence corners, rubbish and grass. The best way to combat them is to destroy them by burning them in their winter homes during winter or early spring. They may be prevented from going to other fields after the wheat is harvested by plowing a strip of soil around the field 6 or 8 feet wide, mulching the soil thoroughly, and dragging a deep furrow in the plowed strip. Chinch bugs are unable to surmount a pulverized furrow. The progeny of one female chinch bug under favorable conditions will number 50,000 to 60,000 in one season. An ounce of prevention is worth a pound of cure in combating chinch bugs.

12. *Harvesting wheat at the proper time* and taking proper care of it are important factors in getting a good quality of wheat.

Hunt says in his book, *The Cereals in America*, that "Wheat continues to increase in the weight of grain from the time it is formed until it is hard and dry." Most authorities agree that wheat may be cut when the straw begins to turn yellow, and the kernels are just past the dough stage. The kernels will mature

FIG. 13. — The average acreage wheat yield in the United States is about 15 bushels. By practicing the points above suggested the yield may be approximately doubled.

nicely from the nourishment stored in the stems, and the plant and leaves have better food value when cut fairly early. Slightly early cutting often evades lodging of wheat from storms, and, of course, prevents shattering.

The shocking of wheat as soon as it is cut protects the grain

and straw from the hot sunshine, gives the kernels a slightly better color, and facilitates the transfer of nutrients in the stem to the kernel. Placing a bundle or two as cap sheaves on the shock protects the grain from sunshine and rain, and helps in producing and maintaining the best quality in the grain.

Stacking wheat, after it is sufficiently dry in the shock, also will help to improve the quality of wheat. Stacked wheat will usually sell for 10 to 15 cents per bushel more than wheat that is threshed out of the shock. Wheat that is stacked goes through a sweating process which brightens the kernel and reduces the moisture in the kernel to such an extent that it will usually keep well when stored in bins. It requires from 3 to 5 weeks for wheat to go through the sweating process.

Farmers should build granaries of such capacity that from one-half to three-fourths of their wheat crop could be stored, and then marketed at different seasons of the year. Such a practice would mean a higher average price to the producer, a smaller chance for the speculator and lower prices to the consumer.

Uses of wheat. — The wheat crop is the most cosmopolitan crop grown and used in the world. It is connected with the welfare and comfort of more people than any other one product. Wheat is produced in almost every nation; and its demand and price fluctuate according to the success or failure of production in the various parts of the world.

Wheat is used almost exclusively for human food; however, a small amount of wheat and the by-products of the manufacture of flour are fed to domestic animals. Hunt says, "The value of wheat as a food does not lie so much in its superiority in sustaining life, as it does in its greater palatability and the attractiveness and great variety of forms which can be made therefrom." It would be difficult to name all the fine human food products made from wheat. Wheat is indeed the "staff of life."

Let us examine the digestible composition of 100 pounds of wheat, in comparison to 100 pounds of corn.

Percentage Digestible Composition of Wheat and Corn

	Total Dry Matter in 100 Lb.	Digestible Nutrients in 100 Lb.				Nutritive Ratio	Therms[1]
		Crude Protein	Carbo-hydrate	Fat	Total		
Wheat	89.8	9.2	67.5	1.5	80.1	1 : 7.7	82.63
Dent corn	89.5	7.5	67.8	4.6	85.7	1 : 10.4	88.84

Time spent in thoroughly examining the above table, and in memorizing it, as one would learn the multiplication table, is time well spent. Wheat and corn have practically the same amount of dry matter, namely, 89.5 lb. in each 100 pounds; wheat has 9.2 per cent digestible protein, and corn has 7.5 per cent; the amount of starch in each is practically identical; but corn yields 4.6 per cent fat as against 1.5 per cent in wheat.

The nutritive ratio of wheat is as 1 : 7.7 and of corn 1 : 10.4, showing that wheat contains more protein in proportion to the carbohydrates and fats than does corn. That is, wheat is more nitrogenous than corn. The heat producing value of corn is 88 therms, and of wheat is 82 therms per each hundred pounds. Of course, wheat and corn are not used extensively as fuel to heat buildings, because wood and coal can be purchased for a fourth to half the cost of wheat and corn. A hundred pounds of *good* coal yields 350 therms of heat.

The entire wheat grain furnishes more food per 100 pounds than any of the wheat products. In the manufacture of flour the covering of the kernel and the germ are removed, two important parts of the kernel, as far as food value is concerned. In fact the germ and the bran contain more mineral matter and protein material than the white starchy part of the kernel, out of which flour is manufactured. The whole is better than a part. Too much money and time are spent on the separation of the wheat kernel.

[1] A therm is the amount of heat required to raise 1000 lb. of water nearly 4 degrees Fahr.

Wheat flour, wheat, wheat screenings, middlings and bran have the following digestible composition per each 100 pounds:

PERCENTAGE DIGESTIBLE COMPOSITION OF WHEAT, FLOUR, ETC.

	Total Dry Matter	Crude Protein	Carbo-hydrates	Fat	Total Digestible	Nutritive Ratio
Wheat flour .	87.7	8.1	69.6	0.9	79.7	1 : 8.8
Wheat . .	89.8	9.2	67.5	1.5	80.1	1 : 7.7
Wheat screenings . . .	89.8	9.6	47.3	3.6	65.0	1 : 5.8
Wheat middlings . .	89.6	13.4	46.2	4.3	69.3	1 : 4.2
Bran . . .	89.9	12.5	41.6	3.0	60.9	1 : 3.9
Wheat straw	91.6	0.7	35.1	0.5	36.9	1 : 51.7

Sixty pounds of wheat may be made into the following products under different conditions and milling processes:

FLOUR, BRAN AND SHORTS MADE FROM 60 POUNDS WHEAT

	Flour of Various Kinds, Pounds	Bran, Pounds	Shorts, Pounds
From 60 pounds wheat .	40	10	10
From 60 pounds wheat .	35 patent flours 7 low grade flours	10	8
From 60 pounds wheat .	8 high grade flours 26 medium grade 10 low grade	8	8
Government recommends	45 pounds flour	15 pounds shorts and bran	

The Government's recommendation is good because it requires less work to separate the same grain into two or three products than to separate it into five products. Flour mills charge a heavy tax for separating wheat into fine products which do not improve the product as far as food value is concerned. In fact, coarse flour, with much of the bran left in it, is more nourishing than the finely milled, very white flour.

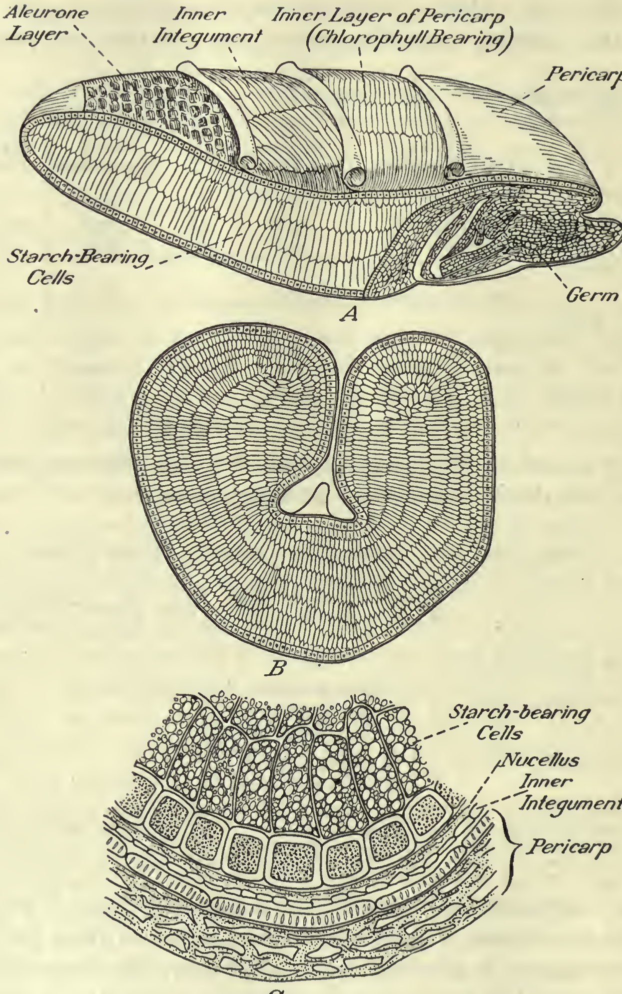


FIG. 14. — The parts of a wheat kernel. The bran is the richest in nutrients of any part of the kernel, especially in protein and mineral matter.

According to the census estimates the average amount of wheat consumed by each person in the United States at different periods was as follows: [1]

1890	5.29 bu.
1900	5.31 bu.
1910	5.44 bu.

In addition to the above consumption about $\frac{1}{11}$ of the entire crop (about 70,000,000 bushels) is used annually for seed wheat. This is approximately $\frac{3}{4}$ bushel per person. Some wheat is used for breakfast foods. The total amount of wheat required, exclusive of exports, for all purposes per capita is about 6.5 bushels.

In 1917 the population of the United States was estimated to be 103 million people. The total wheat yield was estimated to be 587 million bushels. The population, amount of wheat produced and the number of bushels of wheat per capita produced in the United States for three different periods follows:

SOME FACTS ABOUT WHEAT AT THREE PERIODS IN THE U. S.

YEAR	WHEAT PRODUCED BUSHELS [2]	POPULATION [3]	BU. OF WHEAT PRODUCED PER CAPITA	EXPORTS BUSHELS
1890	399,262,000	62,116,811	6.4 plus	106,000,000
1900	522,230,000	74,610,523	7.0 plus	215,000,000
1910	635,121,000	93,402,151	6.8 plus	69,000,000

The percentage of the entire crop exported in 1890, 1900 and 1910 was 26.6, 41.4 and 10.9 per cent respectively.

We should observe that ordinarily the United States does not produce any too much wheat for her own people, and for that reason our farmers who produce wheat should utilize all the factors that will help to increase the wheat yields.

Summary. — The history of wheat is coextensive with the history of the human race. Wheat and wheat products are more

[1] U. S. Yearbook of Agriculture.

[2] U. S. Yearbook of Agriculture.

[3] U. S. Census Reports.

extensively used by civilized people and mankind in general than any other one crop product. Wheat ranks second of all the crops grown in the United States in value and food produced, corn being first. The cost of bushel production decreases as the yield per acre increases. The price of labor, the price of wheat, the kind of implements used and their cost, and price of other products in general are, of course, factors that affect the economic production of wheat.

The factors influencing production as discussed in this chapter and as worked out at the different experiment stations deserve close study by every one interested in wheat production. In fact, this is the phase of agriculture that deserves first emphasis. But it is likewise true that the economic use of products is just as essential as their production. The entire wheat kernel provides more and better food than any part of it does after it is separated. There is too much time and money spent in separating the wheat kernel through milling processes. Fine pastries should be avoided. The whole wheat product provides more mineral and protein matter; and if the teeth of the race are to be maintained, mineral and protein matter must be provided, for it is often said, "A race is no stronger than its teeth." The production and proper use of wheat tend to conserve our natural resources, and to make our race stronger.

QUESTIONS

1. Discuss the importance of the wheat crop.
2. What are the principal wheat producing countries?
3. Bound the leading wheat districts.
4. How much does it cost to produce wheat?
5. What are the causes of low wheat yields?
6. Why does early plowing increase wheat yields?
7. What is the fly-free date for sowing wheat in your section?
8. What varieties of wheat are recommended for your state?
9. Describe in full the life history of a grain of wheat from sowing to harvesting, where the largest yield is expected.
10. What are the uses of wheat?
11. Why is bran such an excellent feed for dairy cows?

PROBLEMS

1. Secure from some farmer an estimate of the cost of wheat production. Give the material you get in an itemized report to the class.
2. Give in the form of a report the biography of Cyrus H. McCormick.

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CHAPTER III

CORN

History of corn. — Corn is a native of America. The records of voyagers prove that it was grown from Maine to Chile at the time of the explorations of the American continent. Several varieties of corn have been found in the ancient tombs of Mexico, Peru, Chile and the Central American States. These tombs are known to be 2000 years old, proving that corn has been cultivated for upwards of 2000 years. From corn the Indians made a number of substantial foods. Corn was readily used by the colonists and often prevented them and their stock from starving.

Columbus is said to have taken corn back to Spain. From there it was soon disseminated over Europe, Africa and Asia. But the real home of corn is still in the land of its birth, for three-fourths of the entire corn crop of the world is grown in North America. Illinois, Iowa, Missouri, Nebraska, Indiana, Kansas and Ohio produce over half (58 per cent) of the corn crop of the world.

Importance of corn. — Corn is the most important crop grown in the United States. In fact, there are as many pounds of corn grown here as there are of all other crops combined. The acreage, production and value of the leading farm crops for 1914–1918 was as follows:

YIELD OF FARM CROPS, U. S. 1914–1918

Crop	Yield per Acre	Acreage	Yield, Bushels	Value in Dollars
Corn . . .	25.7	107,980,000	2,279,700,000	$2,638,000,000
Oats . . .	33.7	42,790,000	1,416,600,000	773,800,000
Wheat . . .	15.1	45,035,000	822,088,000	973,970,000
Potatoes . .	96.6	3,917,800	379,460,000	371,900,000
Barley . . .	27.7	8,200,000	174,570,000	171,927,000
Rye	17.7	3,853,000	59,247,000	76,000,000
Rice	37.9	971,000	33,689,000	45,520,000

During the period 1914 to 1918 inclusive, the average annual yield of corn was 2,279,700,000 bushels and of the rest of the crops given in the above table 2,885,654,000 bushels, showing that corn produced practically as much feed as all the other crops combined.

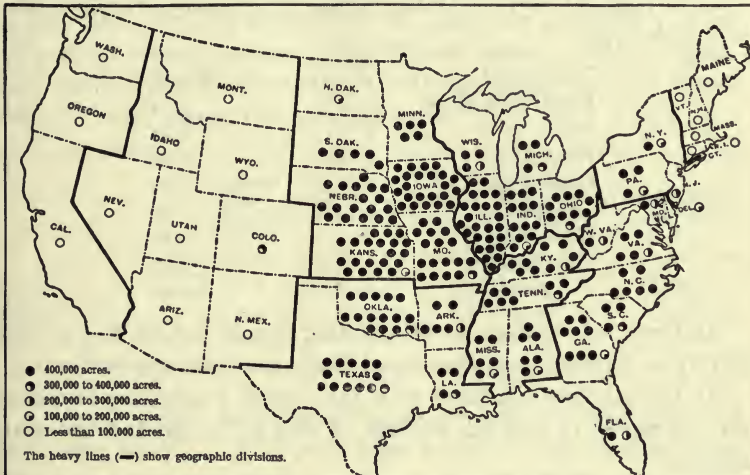


FIG. 15. — Corn acreage by states, 1909.

The above map taken from the 1910 Census Report shows the acreage distribution of corn production.

The following graph gives the yearly corn production of the Corn Belt States.

CORN PRODUCTION IN BUSHELS

	Bushels	0% 5% 10% 15%
United States	2,279,700,000	
Iowa	368,234,000	16.1%
Illinois	348,957,000	15.3%
Nebraska	190,383,000	8.3%
Indiana	179,149,000	7.8%
Missouri	175,552,000	7.7%
Ohio	138,593,000	6.0%
Kansas	102,455,000	4.4%
Rest of the United States		34.8%

Data for 1914 to 1918 taken from the U. S. Yearbook of Agriculture. Iowa, Illinois and Indiana produce annually over one-third of the corn crop of the United States.

The United States produces 75 per cent of the corn crop of the world; Europe, 15 per cent; South America, 4 per cent; and the rest of the world about 6 per cent.

Cost of corn production.[1] — From data collected from about 5000 farmers all over the United States the cost of corn production was as follows:

Land rental	$ 3.75
Preparation of soil	2.11
Seed	0.24
Planting	0.44
Cultivation	2.24
Fertilizer	.62
Harvesting	2.20
Miscellaneous	0.47
Total	$12.07

At three sub-stations in Minnesota[2] it cost $16.86, $13.50 and $13.85 to produce, cut, shock and haul corn from the field.

At the Missouri Station,[3] with the cost of production obtained on 357 acres, it cost an average of $13.52 to produce an acre of corn.

The acreage cost of corn remains fairly constant. But the cost to produce a bushel of corn varies with the amount of corn produced. When a yield of 60 bushels is produced, the cost per bushel is about one-half as much as when only 30 bushels are produced.

Reasons for corn production. — Corn holds an important place in American agriculture for the following reasons:

1. Corn thrives well in many soils and under many conditions. It is grown in every state in the union. Different varieties of corn range in maturity from 90 to 200 days.

2. Corn is grown because it is a cultivated crop — that is, intertilled. This helps to clear the land of undesirable weeds.

3. Corn is grown because it fits into the crop rotations practiced. Corn, oats and wheat is a common rotation followed. And occasionally a red clover crop is introduced into this rotation.

[1] April Crop Reporter, 1911. [2] Bulletin No. 145. [3] Bulletin No. 125.

4. Corn is grown and will continue to be grown, because it is generally fed upon the farms where grown. This tends to maintain the fertility of the soil, and is conducive to a permanent agriculture.

5. Corn produces more food per acre than the other cereal crops. It is for this reason that in 1909 corn occupied 51.4 per cent of all cereal acreage in the United States.[1] The comparative yield, number of pounds, total digestible food and money value of corn, wheat and oats follows:[2]

	Average Yield per Acre Bushels	Average Yield Pounds	Total Digestible Food per Acre Pounds	Money Value per Acre
Corn	26.6	1490	1286.5	$14.92
Wheat	15.0	900	720.0	13.02
Oats	30.0	960	672.0	11.82

6. Again corn is raised so generally because it is the great fuel producing food. It is to the animal kingdom what coal is to the

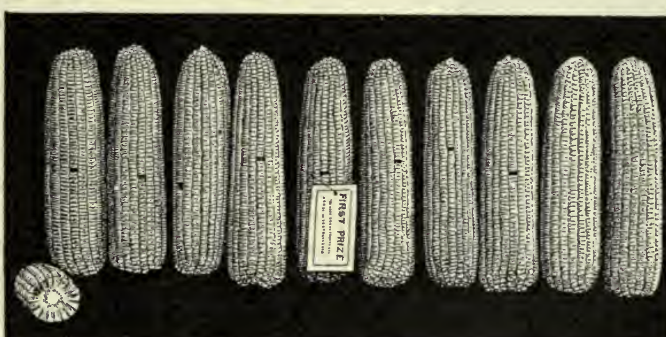


Fig. 16. — A good ten-ear sample of corn.

homes. According to Henry and Morrison, *Feeds and Feeding*, "Corn is the great energizing, heat-giving, fat-furnishing food for

[1] U. S. Census Report.

[2] U. S. Yearbooks of Agriculture. 1905–1915 inclusive.

the animals of the farm." It is for these reasons that such an enormous quantity of corn is produced.

Types of corn. — There are six types of corn: dent, flint, pop, sweet, soft and pod corn. Of these the first four are of commercial importance.

Dent corn is so named because upon maturing the crown of the kernel becomes indented from the shrinking of the soft starch. Practically all of the world's corn crop — at least 90 per cent — is of this type and it is the variety chiefly produced in the corn belt. Many varieties — more than a hundred — have been developed of this type of corn.

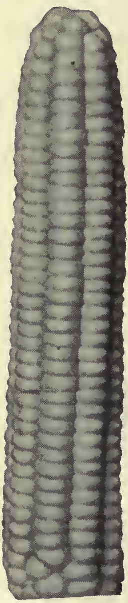


Fig. 17.—An ear of flint corn.

Flint corn is so named because of its flinty, hard kernel. It is the type grown almost wholly in the New England States, because it matures earlier than the varieties belonging to the dent type. Although the acreage of corn in the New England States is small comparatively, yet the acreage yield with flint corn for 1907–1916 was 41.4 bushels. This large yield is due to the fact that the New England farmers utilize the factors that are essential to larger crop production.

Pop corn is so named because of its popping attributes. The expansion of the moisture in the hard, horny kernels due to heat causes them to burst open. Pop corn has small kernels and small ears.

Sweet corn, grown for household use, is somewhat transparent, glassy in appearance, and has a shriveled covering. It is called sweet corn because of its saccharine composition. Sweet corn is used green, dried, or canned. The production of sweet corn is increasing as people are learning more how to preserve it for winter use.

Pod corn is the ancestor of all our types of corn. Each kernel of this type of corn is covered by little husks. It is thought that the little receptacles in which the kernels of corn grow are remnants

of the husks of the kernels of the ancestral pod corn. Pod corn deserves historical credit and mention. It was a good parent, though it scarcely resembles its highly developed progeny.

Soft corn is so named because of its soft, white, starchy kernel. It has no hard, horny part in the kernel. It contains only 7.4 per cent protein, while dent corn has 10.1.

Fig. 18.—An ear of pod corn. Note the husk covering each kernel.

The corn plant. — The corn plant belongs to the grass family. This family of plants has the following characteristics: Hollow stems with nodes and internodes, leaves that have parallel veins, and fibrous roots. The corn plant has all these characteristics except that the stalks have pithy interiors. In all other respects practically and botanically speaking the corn plant is like the wheat, oat, or bluegrass plant. There are other important farm crop plants belonging to the grass family which we have not space to mention.

The ideal corn plant varies according to the purposes of growth and selection. Farmer's Bulletin No. 229 states that "A desirable stalk is one without sucker, thick at the base, with well-developed roots, gradually tapering toward the top, and bearing a good ear or ears slightly below its middle point. It is perhaps not advisable even in the Southern States to obtain a taller growth of stalk than 10 feet and in the North the short growing season does not permit of more than half this growth of stalk." The ear on the stalk should be from $3\frac{1}{2}$ to 5 feet above the ground. The shank, about 5 inches long, should be comparatively slender, but strong enough to hold the ear. Experiments by the U. S. Department of

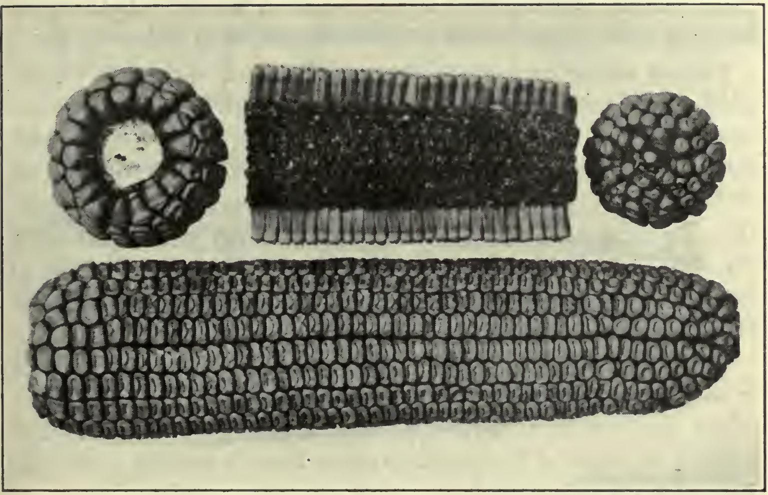
Courtesy of Bowman and Crossley.

FIG. 19.—The stalk on the left is undesirable because it is too tall and slender and would be liable to break down. The right hand stalk is very good.

Agriculture demonstrate that the characters of roots, stalk and stem, quantity of foliage, and number of ears to the stalk are transmitted to a very high degree. Good ears from a good stalk are due to years of selection, an important consideration in selecting seed corn.[1]

An ear of corn varies in size in different parts of the United States according to the length of the growing period. In the corn belt a good ear should be 9–10½ inches long, 7¼–7½ inches in circumference at one-third of the distance from butt to tip and weigh about 8 ounces. An ideal ear is almost cylindrical, the tip is well covered and the butt is cup shaped. The cob is fairly small; a large cob is usually covered with shallow grains.

[1] For descriptive outlines of single ears of corn, and ten ear sample score cards, turn to the Gehrs and James Laboratory manual entitled "One Hundred Exercises in Agriculture."



Courtesy of Farmer's Bulletin.

FIG. 20. — Ears of corn showing good butts and tips and a proper sized cob, and good close-fitting kernels.

Kernels should be uniform in shape and color, and possess the characteristics of the variety. A kernel is about twice as deep as it is wide. The germs should be large, full, smooth, bright and oily. Small, shriveled germs must be avoided in seed corn selection.

The kernels should fit both ways. See figures 21 and 22.

FIG. 21. — Good and poor types. The top kernels came from an ear with too much space at cob, indicating low yield, poor feeding value and immaturity. Compare them with the kernels in the bottom row.

Each ear of a ten ear sample of corn should be uniform in shape, color and size; be true to the variety; be mature; show breeding; and be similar to every other ear in the sample. The sample should come up to the suggestions of the ten ear score card. The kernels should possess the shape of an ideal kernel; be uniform in size,

shape, color and indentation. A sample of corn not possessing the attributes indicated cannot be expected to win in a corn show nor as seed corn.

Factors aiding corn production. — The most important factors aiding corn production are: (1) Proper preparation of the seed bed; (2) Breeding for fairly low ears; (3) Use of good viable seed corn; (4) Time of planting; (5) Depth of planting; (6) Method of planting; (7) Proper cultivation; (8) Rotation of crops; (9) Growing adaptable and prolific varieties; (10) Use of barnyard manures; (11) Proper use of commercial fertilizers; (12) Combating the enemies of corn; and (13) Harvesting corn properly. Each of these factors will be discussed.

1. *Proper preparation of the seed bed* is of prime importance in securing large yields. The points to consider in the preparation of the seed bed are: (1) Distribution of labor; (2) Catching and holding of water; (3) Making plant foods available; and (4) Providing deep, loose, but firm seed bed.

Generally speaking, it is more convenient, as far as labor is concerned, to plow corn land in the fall; and where soils are in good condition this is probably the best practice. It is inadvisable, however, to plow rolling land and clay soils in the fall. As far as yields are concerned the experiment stations have little, and rather inconclusive, evidence to offer, but practically all agree that fall plowing aids in the distribution of labor.

FIG. 22.—If corn is to yield well, it must fit both ways. The kernels in the upper row do not fit.

Fall plowing has the following advantages: (1) The soil is exposed to freezing, which produces a better physical condition of the soil; (2) The organic matter becomes more thoroughly in-

corporated into the soil; (3) The plant foods become more available; (4) The bacterial organisms are more active in a fall plowed soil.

Since corn requires a great deal of moisture, 310 units of water to make one unit of dry matter, it behooves the farmer to practice carefully the kind of seed bed preparation that will catch and hold a maximum quantity of water, except in some instances where drainage must be employed.

Corn prefers a deep, loose, but firm seed bed. However, the depth of plowing that has proved economically most productive has been a depth of 5 to 8 inches. The facts on the relations of depth of plowing to yields are quoted as follows:[1]

Deep vs. Ordinary Plowing

	Ordinary Plowing 7½ Inches Deep	Spaulding Plowing at Depth of 15 Inches	Subsoiling Plowing. Plowed 7½ Inches, Subsoiled an Additional Depth of 7½ Inches
1910	42.13 bushels	38.98 bushels	42.90 bushels
1911	78.49 bushels	76.75 bushels	79.05 bushels
1912	51.08 bushels	54.18 bushels	47.14 bushels
1913	63.20 bushels	71.29 bushels	74.83 bushels
1914	68.55 bushels	64.61 bushels	71.15 bushels
Average	60.69 bushels	61.12 bushels	63.01 bushels

From this data it may be observed that subsoiling and deep plowing cannot be economically practiced ordinarily in corn production. Hunt says in *Cereals in America*, "While in a number of trials satisfactory results have been obtained by plowing four inches deep and less, yet the most generally satisfactory depth, all things considered, would seem to be six inches. As compared with wheat and oats, deep cultivation is advisable."

2. *Breeding for fairly low ears.* — There is a possibility of increasing yields by developing corn with the ears placed rather low

[1] Ohio Station Bulletin No. 282.

on the stalk. The following table shows what may be done by selection in affecting the yield of the corn plant.

SELECTING CORN FOR HIGH AND LOW EARS

	OHIO STATION BULLETIN, 282, FIVE YEARS	ILLINOIS STATION BULLETIN, 132, THREE YEARS
High ears	57.21 bushels	65.9 bushels
Low ears	59.16 bushels	66.9 bushels
In favor of low ears	1.95 bushels	1.0 bushels

To quote the Ohio Bulletin, "The early light stover strain excels in yield of grain particularly in seasons of low rainfall. It is easily possible to overdo the matter of selection for low ears. It, however, seems evident that by continuous selection it is possible to develop a variety of corn with lower-borne ears, and yet secure as much grain as with a strain bearing more than 50 per cent more stover." See cut, page 6.

3. *Good seed corn is an important point in increasing corn yields.* — Seed corn should possess all the characteristics desirable in a corn in the locality in which it is to grow. Will it grow; will it mature; and will it produce a maximum amount of good marketable corn to the acre? These are a few of the tests of seed corn.

If corn is to yield, it must possess those qualities described in a previous paragraph, and it must grow. No one can tell whether corn will grow or not until it is tested. In Iowa[1] the average stand is not more than 62 per cent. The average yield in Iowa 1912–1916 was 366,000,000 bushels. A perfect yield on a 100 per cent stand would have been 590,000,000 bushels, or a difference of 224,000,000 bushels, the value of which at 50 cents per bushel would be $112,000,000, — enough to run the average state university for 112 years. The poor stand of corn is due to several causes, the main one of which is the planting of seed that has not been tested. The average corn yield in the United

[1] Bulletin No. 135.

States is 27 bushels to the acre. If 27 bushels to the acre represents 62 per cent of a yield, then a 100 per cent yield would be 43.5 bushels.

Seed corn selection should be made in early fall, when the corn is maturing. Twice as much as is needed should be gathered

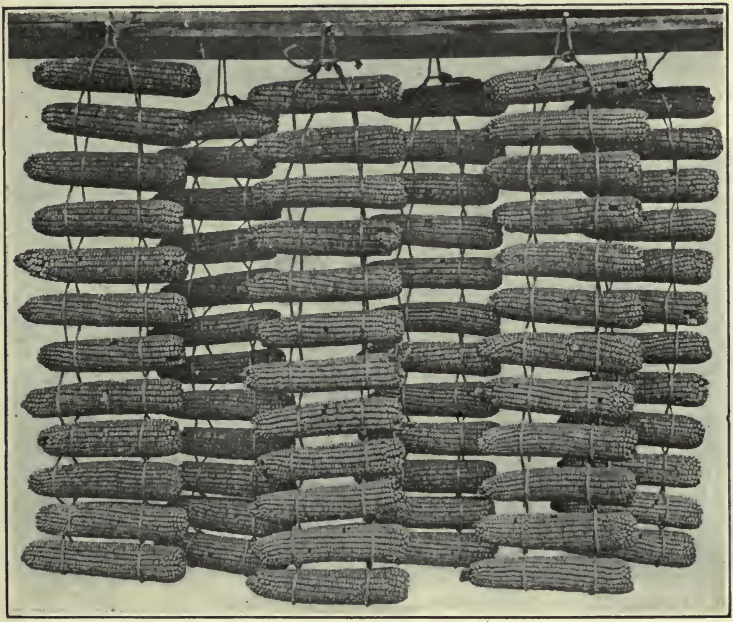


FIG. 23. — Seed corn hung up with a binder twine. A good way of storing seed corn.

and carefully dried. What are the advantages of early fall gathering of seed corn? They are:

1. The character of the stem can be examined and the securing of seed corn from stalks with undesirable leaf and shank characteristics prevented.

2. The conditions under which the plant grew can be observed. Where other conditions are the same, ears should be selected from stalks that are prolific.

3. The corn can then be dried, so that early fall freezes cannot freeze the moisture in the seed corn, and thereby burst or break the small germ in the kernel. We should think of the seed kernel as containing the corn plant of the following season. And as a calf needs some protection from cold, so likewise should the corn kernel be protected. Seed corn is stored in an attic or elsewhere, where it will dry.

There are two means of testing seed corn — the germination box and the rag doll tester. Any sized box containing 4 to 5

FIG. 24. — Testing seed corn.

inches of coarse sand or sawdust may be used as a germination box. The sand is thoroughly compacted; a white muslin cloth marked into 2 × 3 inch squares is laid over the sand. Six kernels from each ear, taken from three places of the ear, are put into a square. Another cloth is placed over the kernels, about $\frac{1}{4}$ inch of sand over it, and another cloth over the sand. A box 20 × 30 inches is large enough to use in testing 100 ears; and 100 ears, if they are all good, will plant 7 to 8 acres.

In the rag doll tester a white muslin cloth is marked into squares and six kernels of corn put into each square. After all

the squares are filled, the cloth is rolled up firm enough to hold the corn in place, tied, and then set in a bucket containing two or three inches of water. The bucket should be kept covered and

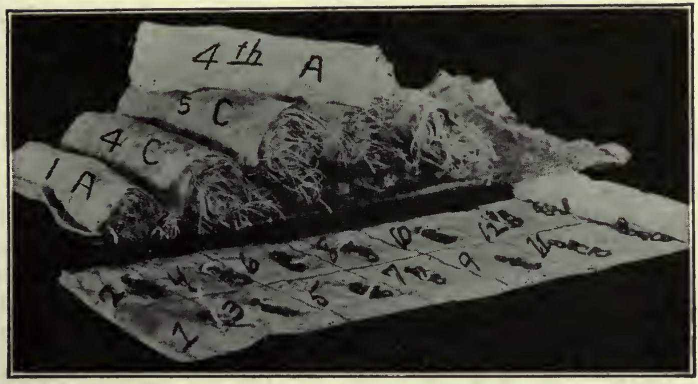


FIG. 25. — The rag doll seed tester. The numbers on the cloth correspond to numbers on ears.

warm. The corn must not be in the water. If favorable conditions prevail the test will be ready to read in about 8 days. All ears and squares should be marked correspondingly, so that no errors will be made when the test is finished.

Ears with poor vitality in germination should be discarded, for it has been shown that corn germinating strongly will yield at the rate of 80 *bushels, when medium and weak germination will yield* 40 *and* 20 *bushels respectively.* Much corn that appears to have excellent qualities will germinate poorly. To illustrate, at the Iowa Station, in 397 tests, 65 per cent germinated strongly; 23.8 per cent weakly; and 11.2 per cent badly. Hence the importance of seed corn selection and testing in securing larger corn yields.

Home grown seed is generally more productive than foreign grown seed. At the Kansas Station[1] in 40 crops of each the average yield from home grown seed was 54.25 bushels; and 47.76

[1] Bulletin No. 193.

bushels from seed not grown in Kansas. This was an excess of 6.57 bushels in favor of home grown seed.

4. *Time of planting is a factor in aiding increase of corn production.* The Indians held that the time to plant corn was when the leaves of oak trees were about the size of squirrels' ears. This is very indefinite, but no definite date can be set for corn planting time. However, after the season has really opened, early plantings yield more, as a rule, than late plantings. From the Ohio Station[1] the following data are quoted:

Bushels of Shelled Corn per Acre from Early and Late Plantings

	Apr. 24–29	May 4–10	May 14–17	May 25–28	June 2–6
1908	30.16	56.02	61.68	50.66	40.88
1909	100.19	98.94	91.08	81.34	62.88
1910	42.45	37.14	37.27	27.67	20.19
1911	67.04	75.96	73.76	54.83	43.95
1912	65.87	64.12	66.99	49.38	44.95
1913	77.43	78.75	76.64	65.36	53.04
6 year average	63.86	68.49	67.37	54.87	44.32

The table indicates that plantings made from May 4 to 10 in a 6 years' test produced the largest yield, and that plantings made during this period yielded an annual average of 4.17 bushels more per acre than corn planted from June 2 to 6. The bulletin says that "Here is evidently an opportunity for adding a few bushels to Ohio's corn yield."

5. *Depth of planting also affects the corn yield.* — The table at the top of the opposite page gives the facts as they have been reported from two stations.

This table is self-explanatory. The depth of planting varies with the type of soil, amount of moisture in the soil, and the time of season. Corn may be planted deeper in a sandy soil than in a heavy clay. In wet soils corn should be planted shallow; in dry soil, deeper. Plant corn deeper in early spring than later. A depth of $1\frac{1}{2}$–2 inches may be recommended for corn planting.

[1] Bulletin No. 282.

DEPTH OF PLANTING

	ILLINOIS STATION[1] FIVE YR. AVERAGES	OHIO STATION[2] SIX YR. AVERAGE	ILLINOIS STATION[3] THREE YEAR AVERAGE
One inch deep . .	78 bushels	60 bushels	90.2 bushels
Two inches deep . .	72 bushels	51 bushels	81.4 bushels
Three inches deep .	65 bushels	46 bushels	74.0 bushels
Four inches deep .	69 bushels		77.8 bushels
Five inches deep . .	61 bushels		72.1 bushels

6. *Method of planting affects production to some extent.* — There are two methods commonly practiced in planting corn; namely, drilling and checking. A third method, kernel-spacing, *combines* the advantages of both drilling and checking. The advantages of drilling corn are: (1) The corn plants stand singly and therefore a maximum amount of soil is exposed to the growing roots; and (2) It requires less care in planting.

FIG. 26. — Hill of corn planted by a modern check rower. The central stalk had no chance to develop either below or above ground, and produced but a nubbin.

The disadvantages of drilling are: (1) It is difficult to control weeds for the corn can be tilled only one way; (2) In wet seasons the hoe must be employed to a great extent.

Checking corn has the following advantages: (1) It can be cultivated each way, and be kept free from weeds; and (2) The entire surface of the soil can be kept in good condition.

[1] Bulletin 31. [2] Ohio Report 1890. [3] Bulletin 13.

FIG. 27. — Kernel-spaced checked corn. For a foothold each plant needs a cubic foot of space.

The disadvantages of checking are: (1) The plants are usually crowded, thus some of them are stunted. (2) The roots also become crowded and not sufficient plant food can be made available in such a restricted root surface exposure.

The advantages of kernel-space checking are: (1) Since the roots are not crowded, the plants can secure more soil moisture and therefore more plant food; (2) The kernel-spaced corn permits more sunlight to each plant; and (3) It has in every case where tried yielded better than the other two methods of corn planting. Farmer's Bulletin No. 400 gives the following:

COMPARATIVE YIELDS OF CORN WHEN KERNEL-SPACED CHECKING, AND THE USUAL METHOD OF CHECKING WERE EMPLOYED

	TESTS AT ROUND HILL, VIRGINIA	TESTS AT PIKETON, OHIO	TESTS AT MCLEAN, VIRGINIA
Kernel-spaced . .	55 bushels	118.5 bushels	64 bushels
Usual method . .	53 bushels	114.0 bushels	61 bushels

7. *Corn cultivation.* — The supreme purpose of cultivating corn is to *increase the yield.* There are three things which should be kept in mind in the cultivation of corn. They are: (1) Keeping out the weeds; (2) Conserving the soil moisture; (3) Preventing breaking the roots of the corn plant.

(1) *Weeds* in corn are a nuisance. Their effects upon yields are indicated in the following data:

WEEDS REDUCE CORN YIELDS[1]

	Weeds Kept Down by Scraping with Hoe Not Cultivated	Weeds Allowed to Grow	Loss Due to Weeds
8 year average . .	45.9 bushels	7.3 bushels	38.6 bushels

Both plots in the above case were plowed, prepared and planted in the same way. The field in which the weeds were scraped off with a hoe yielded at the rate of 45.9 bushels to the acre, and the plot where weeds were allowed to grow yielded at the rate of 7.3 bushels per acre. The weeds reduced the yield 38.6 bushels per acre.

At the Ohio Station[2] the bad effects of permitting weeds to grow in the corn and the good effects of cultivating are indicated in the following table:

	Ordinary Cultivation 4 to 5 Times	No Cultivation. Weeds Allowed to Grow	Loss Due to Weeds and Gains Due to Cultivation
Three year averages	52.8 bushels	6.7 bushels	46.1 bushels

These tables are very much alike in showing that keeping down weeds is an important factor in corn production. Weeds in corn injure it in the following ways: (1) By using soil moisture; (2) By using plant foods; and (3) By shading and crowding out the sunshine from the plant.

(2) *Soil moisture* is a very important factor in corn production. King, of the Wisconsin Station, determined that it required 310 pounds of water to make one pound of dry matter in corn. Experiments at the Nebraska Station indicate that the water requirement

[1] Illinois Station Bulletin No. 181. [2] Annual Reports II to VI.

for maturing a 50 bushel corn crop is equal to a rainfall of 8 inches. Most of this is required during the months of July and August, as suggested below:

June	0.50 in.
July	3.60 in.
August	3.60 in.
September	0.60 in.

In Missouri the average annual rainfall for July and August for 17 years (1900–1916) was 4.07 and 4.02 inches respectively. According to a report of the State Board of Agriculture of Missouri the relation of a wet July and August to corn yields is brought out by the following:

	Rainfall		Yield per Acre Bushels
	July	August	
1901	2.02 inches	1.88 inches	9.9
1916	1.25 inches	4.05 inches	19.0
1905	7.45 inches	4.69 inches	33.6
1915	6.05 inches	7.86 inches	30.5

"A dry June and a wet July, for a bumper corn crop" is the common saying among farmers.

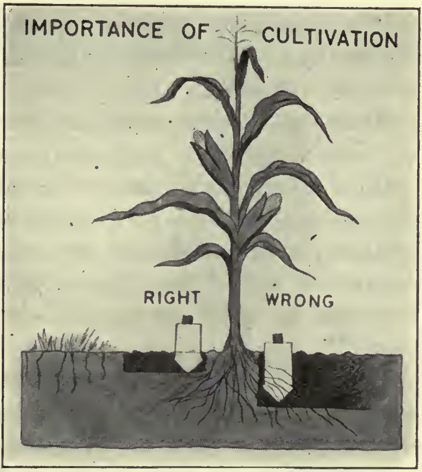
The above points are made to indicate how necessary soil water is to a bumper corn crop. But if the amount of rainfall is limited, how may the farmer secure the greatest corn yield? While this subject is treated in the chapter on Soil Water, we wish to give the following data as showing how yields may be increased under these conditions. Shallow cultivation has given better results than deep cultivation at almost all experiment stations. The results obtained at four stations are indicated on the opposite page.

At the Indiana Station the depth of cultivation was 2 and 3 inches respectively. At the Ohio Station, 1½ and 4 inches.

Deep Versus Shallow Cultivation

	Missouri Station, Bulletin 14, Two Years	Indiana Station, Bulletin 39, Four Years	Illinois Station, Bulletin 39, Five Years	Ohio Station, Bulletin 282, Nine Years
Shallow — Four Cultivations	66.9 bushels	53.5 bushels	70.3 bushels	60.4 bushels
Deep — Four Cultivations	53.5 bushels	50.8 bushels	66.7 bushels	56.4 bushels

In sixty-one tests at 13 experiment stations with shallow and deep cultivation, corn yielded on an average 8.8 bushels more with shallow cultivation. In most cases one to two inches is considered shallow cultivation and 4 or more inches deep cultivation.



Courtesy Soil Improvement Committee.

Fig. 28. — The right and wrong way of cultivating corn. Deep cultivation breaks some of the roots which support the plant.

If the seed bed for corn has been well prepared, there is little need for cultivation except to conserve the moisture and kill the weeds. Oats and wheat produce good crops without being cultivated. Why not corn? In repeated trials, corn that was hoed in order to keep down the weeds has yielded a little better than corn that was cultivated the ordinary way.

That a soil mulch conserves soil moisture is shown by the following:[1]

[1] Nebraska Bulletin No. 5.

EFFECT OF MULCHING ON PER CENT OF SOIL MOISTURE

Depth of Feet	Date of Mulching August 28		September 5		November 5	
	No Mulch	Soil Mulched	No Mulch	Soil Mulched	No Mulch	Soil Mulched
1	25.0	24.8	14.8	16.1	11.1	14.3
2	22.3	22.3	15.5	16.1	9.4	14.5
3	19.8	19.5	15.3	16.0	10.1	13.8
4	15.2	15.5	15.3	16.8	13.3	14.0
5	13.7	12.6	14.5	16.5	13.5	14.4
6	13.6	13.5	14.3	15.5	12.8	14.6
Average . .	18.3	18.0	15.0	16.2	11.7	14.3

It is interesting to study the moisture in the surface foot on September 5 and November 15. The per cent of moisture on the mulched soil was 1.3 and 3.2 inches more respectively. This is a good deal of moisture, especially when a crop needs it.

"Cultivation after each rain is a good practice."[1]

(3) "*The roots* of the corn plant are not grown in excess of the amount needed. If corn has been well prepared, deep cultivation is not advisable and often injures the crop. Deep cultivation should never be done after the corn plants are a foot tall, as much harm would be done by breaking the corn roots."[2]

Nothing is gained in tilling cornfields that are free from weeds, and in which there is a good soil mulch. Saving labor is an important point in economic corn production.

8. *Rotation of crops* is an essential factor in maintaining and increasing the yields of corn. Continuous cropping with corn results in low yields just as with any other crop. The following table shows the result of experiments at the Missouri Station.[3]

[1] Farmer's Bulletin No. 773. [2] Farmer's Bulletin No. 773.
[3] Circular No. 69.

CONTINUOUS CROPPING AND CROP ROTATIONS

	ACRE YIELD OF CORN, 1905
Corn — 17 years	11.8 bushels
Corn, wheat and clover — 17 years	50.7 bushels
Corn, oats, wheat, clover, timothy	54.2 bushels
Corn, wheat, clover (manured) — 17 years	77.6 bushels

In experiments at the Illinois Station[1] similar results were secured, as this table shows:

CONTINUOUS CROPPING AND CROP ROTATION

	ACRE YIELD OF CORN FOR 1904
Corn — 28 years, average for 28 years	22 bushels
Corn, oats, 28 years	36 bushels
Corn, oats, clover, 28 years	59 bushels

Continuous corn for 28 years averaged 22 bushels per acre annually; while in a corn, oats rotation the yield was 36 bushels, and in a corn, oats, clover rotation the yield was 59 bushels of corn.

It should not be concluded from the above experiment that crop rotation will maintain or build up soil fertility, for it will not. However, crop rotation may aid in keeping the soil in fair condition. While crop rotation will be discussed in connection with soil management it may be stated here in terse form that it has the following advantages: (1) It helps to conserve soil fertility; (2) It helps in combating and eradicating fungous, insect, and weed enemies of plants; (3) It helps to improve the physical condition of the soil by supplying organic matter; (4) Different crops need different plant foods. Crop rotations provide for a balanced removal of plant foods from the soil.

9. *The selection of adaptable and prolific varieties in any locality is a very important factor in increasing corn yields.* — No two states

[1] Circular No. 96.

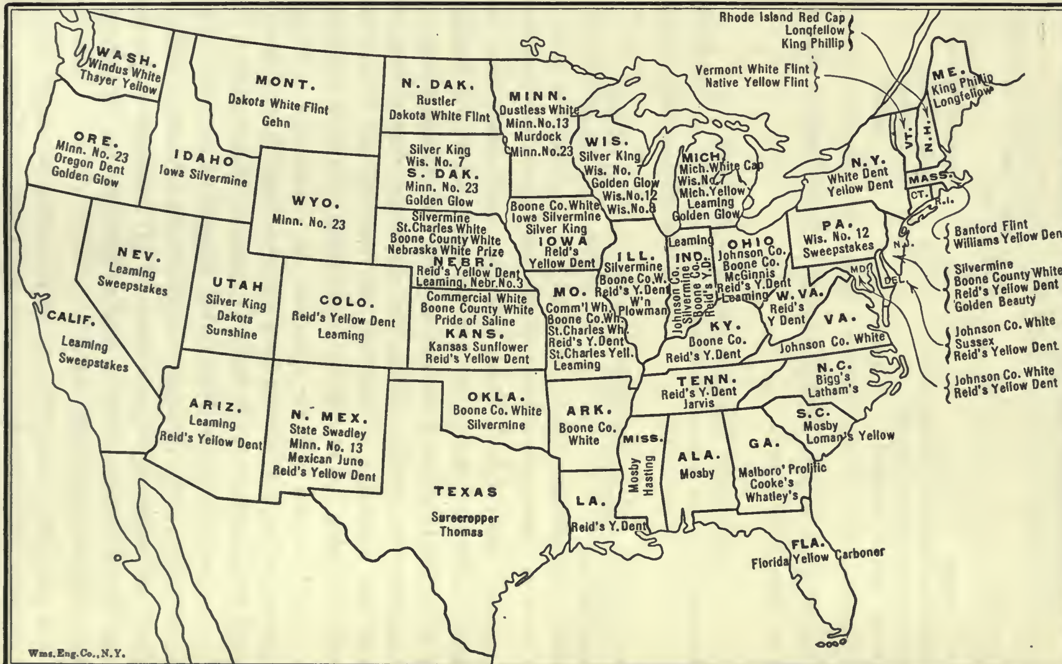


FIG. 29. — Some of the varieties of corn recommended by your State Experiment Station for your state.

present the same conditions as to type of soil, length of season and amount of rainfall; and especially is this true in the corn belt states. It is for these reasons that each state, and also each locality, must develop or improve varieties of corn suited to its particular conditions. The chief agronomist of the state experiment stations may even recommend several varieties of corn for one state. For illustration, the conditions of southern Illinois are so different from those of northern Illinois that entirely different varieties of corn are recommended, on the basis of experiments covering a number of years. Western Kansas has entirely different conditions from eastern Kansas. As the conditions are different, so must the variety of corn planted be different. It is best to consult your own station as to what variety to use, explaining when the request is made whether your soil is upland or lowland and in what section of the state you reside. Then rational advice can be given.

At the Missouri Station[1] from experiments extending over ten years the following average results were secured:

YIELDS OF THE LEADING VARIETIES OF CORN AT COLUMBIA DURING THE TEN YEAR PERIOD 1905–1914

	1905–1914 Bu.	1906–1914 Bu.	1909–1914 Bu.
Boone County White	52.26	50.08	47.06
St. Charles White	53.08	53.08	46.59
Reid's Yellow Dent	51.07	52.11	50.10
Cartner	50.18	50.29	51.04
Leaming	50.22	50.68	47.74
Iowa Silverine	43.49	42.28	40.97
St. Charles Yellow		52.53	48.45
Johnson County White		51.45	46.42
Hogue's Yellow Dent		46.39	47.37
Commercial White			57.44
Cob Pipe			51.20
Hildredth's Yellow Dent			50.33
Clay County White			45.60
Pride of the North			23.29

[1] Bulletin No. 143.

It will be noted from the above table that most of the varieties yielded close to 50 bushels per acre, but the lowest yielded only 23.29 bushels. This clearly indicates that some varieties are better adapted to given conditions than others.

Courtesy Dept. of Iowa Public Instruction.

FIG. 30. — These three ears came from the same hill. The difference between them is due to the producing power of their parents.

Within the same variety, strains may be developed that are more prolific.

The small ear produced about 200 kernels of a poor grade of corn, while the large ear produced about 1000 good kernels — the

one was producing at the rate of 7 bushels to the acre, while the other one was producing at the rate of 45 bushels to the acre. The ears grew in the same hill with the same cultivation, plant food and sunshine. The difference in productivity was simply due to heredity. The farmer should select from the most productive variety those ears that come from stalks that are prolific. Seed corn must be gathered with discriminating judgment.

10. *Barnyard manure* is a powerful factor in maintaining and increasing corn yields. No better evidence could be given on the importance of manure in corn production than to cite a few instances in which its effect has been tried out by the experiment stations.

Manure in Corn Production — 20 Years

In Four 5-Year Periods[1]

	Treatment	Application per Acre		Avg. Yield per Acre, Bushels				Avg. Yield for 20 Years
		Per Crop	Per 5 Years	First Period	Second Period	Third Period	Fourth Period	
Continuous	None		None	26.26	16.76	10.43	8.44	15.47
Continuous	Manure	5 tons	25 tons	40.73	45.52	59.75	55.83	51.81

Five tons of manure applied annually per acre caused the difference in yield between 51.81 bushels and 15.47 bushels, or 36.34 bushels. This increase in yield at the rate of 50 cents a bushel caused the manure to be worth $3.63 per ton.

At the University Farm of the Minnesota Station[2] the following results were obtained:

Manure and Corn Yields per Acre — 1909–1914 Inclusive

Fertilizer	Amount per Acre	Average Yield per Acre	Resulting Increase Due to Manure
None		52.55 bushels	
Barnyard manure . . .	6 tons a year	57.92 bushels[3]	5.37 bushels

[1] Ohio Bulletin No. 282 [2] Bulletin No. 57. [3] Average of check plots.

The table is self-explanatory. However, we should call attention to the point that the manured plot will continue for a number of years to maintain yields above those produced by the plot not manured. And for that reason it is difficult to assign a definite value to the manure put upon the above experimental plot.

11. *Commercial fertilizers* may, under some conditions, become an important factor in corn production. However, it is generally conceded that at the present time an intelligent use of legumes and barnyard manures with crop rotation may prevent a reduced corn yield. Hunt says: "Stations west of the Alleghany Mountains have found but very little gains from the use of commercial fertilizer. Practically all agree that the maize plant does not respond as readily to the use of commercial fertilizers as do the smaller cereals which are sown broadcast and thus have so many more plants to the acre and which grow during a cooler portion of the year."

Sixteen years' experimentation with fertilizers at the Ohio Station brought the following results.

Fertilizer Tests with Continuous Corn Culture [1]

Averages for Years 1894–1909

Fertilizing Materials — Pounds per Acre		Yield, Bushels	Increase
None		22.22	
Acid phosphate . . . Muriate of potash . . . Nitrate of soda . . .	160 pounds 100 pounds 160 pounds	42.71	20.49 bushels

It will be observed that the fertilizer used had 20.49 bushels to its credit yearly for the 16 years. This is an important gain, and one which cannot fail to arouse the consideration and thought of any farmer who is producing corn. However, as was stated before, other farm practices should be employed to maintain soil fertility and production.

[1] Circular 104.

Wilson and Warburton say: "A good corn fertilizer should contain about 8 per cent phosphoric acid, 5 to 6 per cent nitrogen, and 5 to 9 per cent potash. About 300 to 500 pounds per acre may be applied."

12. *Diseases and insects affecting corn production* may be taken up in the class discussion, but for lack of space in this volume it will be impossible to treat this subject adequately here. It is advisable that other sources be used in the study of the important enemies of the corn crop.

13. *Harvesting corn properly* is an important factor in getting maximum value from the corn crop. The purposes in harvesting are to secure the maximum amount of digestible food at a minimum cost.

FIG. 31. — Filling the silo, using a tractor for motor or pulley power.

The silo is an important factor in getting the most feed out of corn, and has the following advantages:

1. It prevents the loss of 20–30 per cent of the feed value of corn. If corn is shocked, 12 acres will yield no more feed than 9 acres if it is put into the silo.

2. It adds palatability and succulency to the feed.

3. Silage replaces high priced hay. Silage reduces the cost of

the ration, for 30 bushels of corn produce about 6 tons of silage, while clover hay will yield but about $1\frac{1}{2}$ tons per acre. Three tons of silage have about the feeding value of 1 ton of red clover.

4. Silage keeps the digestive tract of animals in good condition.

5. Silage produces milk, beef, mutton, more cheaply than other feeds, except pasture. However, a nitrogenous feed must be fed to balance the ration when silage is fed.

It is for these reasons that we recommend the silo — especially where a farmer has sufficient live stock to warrant its construction and use. Figure 31 shows a good type of silo.

The principle of the silo. — Foods and feeds are preserved by canning, drying, salting, pickling, cold storage, and ensiling. Bacteria that cause decay need heat, moisture, air and food. In each method of food preservation one or more of these factors of bacterial growth must be absent. The silo excludes the air. If the silo is not air tight, the silage spoils. The materials used in silo construction are wood, concrete blocks, brick, solid cement, glazed tile, and sheet steel. The pit silo dug in the ground is used in the West. No material in silo construction has superiority over any other in improving the quality of the silage. The main thing in silo construction is to make the walls absolutely *air tight.*

Corn will yield silage at the following rates:

30 bu. corn	6 T.
45 bu. corn	9 T.
60 bu. corn	12 T.

SILAGE FEEDING TABLE FOR 182 DAYS

No. of Cows	Estimated Capacity, Tons	Diameter, Feet	Height, Feet
7	26	10	20
14	51	10	30
21	73	12	32
30	109	14	34
40	143	16	34
50	181	18	34

In former years immature corn was put into the silo. But experiments show that corn yields the most dry material in the most digestible form when the corn is almost ripe; that is, when the husks are turning white, and the lower three or four leaves are beginning to get dry. Corn should not be so dry that it will not pack well when put into the silo. If corn contains less than 65 per cent moisture when put into the silo, enough water should be added to make it pack well.

The following table indicates how the dry material in corn increases up to the time when corn is ripe:

DRY MATTER INCREASES UP TO MATURITY

CONDITION WHEN HARVESTED	APPROXIMATE DATE	YIELD OF DRY MATTER, POUNDS PER ACRE			
		New York Station Annual Report 1889	Michigan Station (Farmer's Bulletin 97)	Kansas State (Bulletin 30)	Average
Ears in silk	Aug. 10–15	3000	3670		3335
Ears in milk	Aug. 25	4300	5320	6868	5496
Ears in glazing	Sept. 15	7200	7110	7716	7342
Ears ripe	Sept. 25	8000	8020	9548	8523

Not only does the dry matter increase, but the total protein, ash, sugar and fat also increase to maturity. The total weight of corn handled decreases somewhat in weight from the green stage to ripening.

INCREASE OF PROTEIN, FAT, DRY MATTER, SUGAR AND STARCH[1]

(Yield per Acre)

	GROSS WEIGHT LB.	WATER IN CROP	DRY MATTER	ASH	CRUDE PROTEIN	SUGAR AND STARCH	CRUDE FAT	CRUDE FIBER
Tasseled	18,045	16,426	1619	138.9	239.8	239.8	72.2	514.2
Silked	25,745	22,666	3708	201.3	436.8	436.8	167.8	872.9
Milk	32,600	27,957	4642	232.6	478.7	378.8	228.9	1262.0
Glazed	32,295	25,993	7202	302.5	643.9	643.9	260.0	2755.9
Ripe	28,460	20,542	7818	364.2	677.8	577.8	314.3	1734.0

[1] Data from Professor Ladd, Geneva Station.

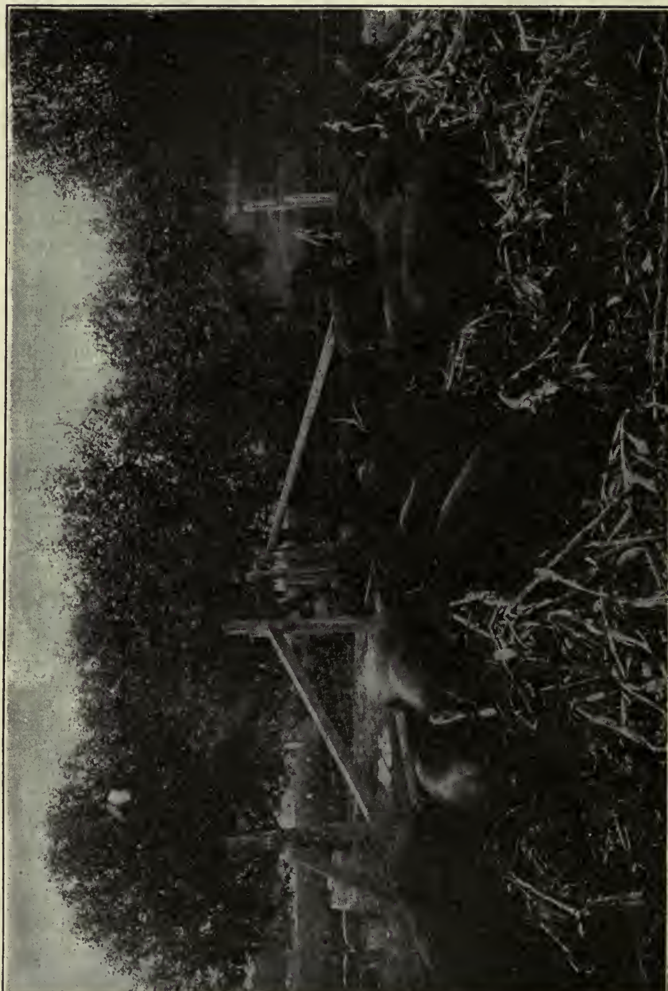


FIG. 32. — "Hogging-off" corn. Good for the hogs, good for the land, and saves labor.

Plants harvested for their stems, leaves and kernels should be cut slightly greener. The best time to cut hay is when about one-third of the plants are in bloom. If hay is made when it is so dry that it will not pack well, it is not in the best condition. Plants gathered for their grains should be well matured when harvested.

"Hogging off" corn saves labor, distributes the manure and puts on more pounds of meat. It costs 6 to 8 cents a bushel to

FIG. 33. — Rail pens without covers sometimes used for storing corn. A wasteful practice.

husk corn. This is saved in the "hogging off" method. Hogs are kept thrifty and in the best growing and fattening condition where they are compelled to take exercise. Disease is less frequent when hogs are out in the open than when confined in close quarters.

Proper methods of cribbing corn are as essential as those practiced in binning wheat. The good crib prevents a loss of 5 to 10 per cent of corn. See figure 34.

6. *Uses of corn.* — Corn and grass are the great meat producing feeds in the United States. No other cereal provides so much feed

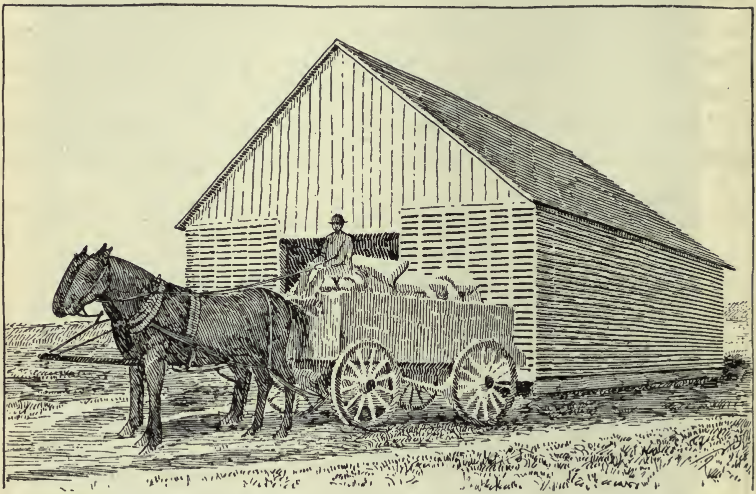


FIG. 34. — Double cribs arranged for both loading and unloading from a central driveway. The eaves should extend farther over the sides.

per 100 pounds at so low a cost as does corn. Pork, beef and milk production is possible to so large an extent because of the corn crop.

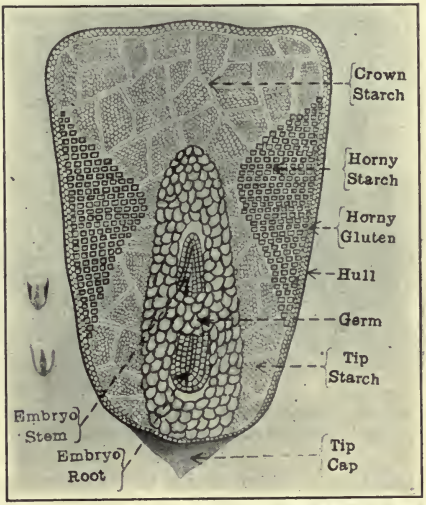
Corn and corn products have the following amount of digestible ingredients per each 100 pounds.

PERCENTAGE DIGESTIBLE COMPOSITION OF CORN AND CORN PRODUCTS

	TOTAL DRY MATTER	POUNDS DIGESTIBLE				NUTRITIVE RATIO
		Crude Protein	Carbohydrates	Fat	Total	
Wheat (for comparison) . .	89.8	9.2	67.5	1.5	80.1	1 : 7.7
Oats (for comparison) . .	80.8	9.7	52.1	3.8	70.4	1 : 6.3
Corn kernels .	89.5	7.5	67.8	4.6	85.7	1 : 10.4
Gluten meal .	91.2	15.1	57.8	4.8	83.7	1 : 4.5
Germ oil meal .	92.2	10.0	50.3	10.0	82.8	1 : 7.3
Corn silage . .	26.3	1.1	15.0	0.7	17.7	1 : 15.1

Corn does not contain quite enough protein to make it a well-balanced ration; therefore, a feed rich enough in protein to balance the ration must be fed with it, — clover hay, alfalfa, soy beans, cotton-seed meal, tankage, or meat scraps.

A number of experiment stations have found that 5 to 6 pounds of corn are required to produce a pound of pork, that 8 to $8\frac{1}{2}$ pounds of corn plus some hay will put on a pound of mutton, and that 10 to 11 pounds of corn plus hay is required to put on a pound of beef. The amount of feed required to put on a pound of meat depends upon the kind of animal, its age and health, and the weather conditions. If 6 pounds of corn are required to put on a pound of pork, when pork sells at 7 cents a pound and corn at 75 cents a bushel, it can easily be determined whether or not it is profitable to feed swine.



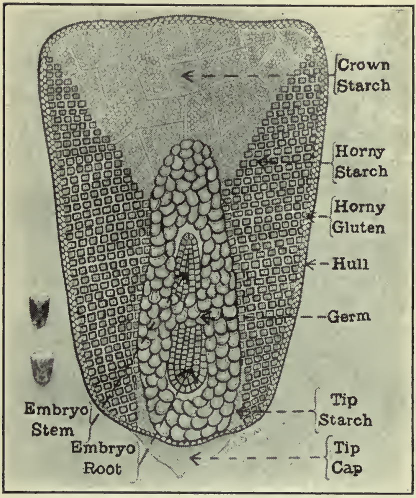
Courtesy Ill. Station.

FIG. 35. — Low-protein corn kernel from drawing. (Small kernels from photograph.)

Many by-products are made from corn. The most important products and by-products are starch, corn meal, breakfast foods, hominy, alcohol and whisky. The husks are used for matting and the pith for packing in ships, for when ships are penetrated the pith expands quickly and closes the opening. Paper is also made from the corn plant, and pipes from the cobs.

Summary. — Corn is a native of America. It was taken to Europe by Columbus; but its real history still centers about America, for about 78 per cent of the crop is grown in North America. The states of Iowa, Illinois, Indiana, Nebraska, Mis-

souri, Ohio and Kansas constitute the corn belt. Corn is grown so extensively in these states because they have an abundance of sunshine and rainfall, — two important conditions for corn production, — and because more food at less cost can be produced with corn than with any other crop.



Courtesy Ill. Station.

Fig. 36. — High-protein corn kernel from drawing. (Small kernels from photograph.)

The factors which affect the production of corn are: (1) A well-prepared seed bed; (2) Breeding for fairly low ears; (3) Tested seed corn; (4) Time of planting; (5) Depth of planting; (6) Method of planting; (7) Proper cultivation; (8) Rotation of crops; (9) Growing adaptable and prolific varieties; (10) Use of commercial fertilizers; (11) Use of barnyard manures; (12) Combating diseases and insect enemies of corn; and (13) Saving the entire crop by the most economic methods of harvesting.

Corn has a number of uses. The most important ones are: (1) To fatten and energize farm animals; (2) To keep farm animals warm; and (3) To provide a number of palatable foods for man.

QUESTIONS

1. Narrate the history of corn.
2. Discuss the importance of the corn crop.
3. Compare the bushel yield of the corn crop with that of wheat and oats.
4. Why is corn a grass, botanically speaking?
5. Discuss the characteristics of the different types of corn.
6. Describe an ideal ear of corn for seed.

7. Why test seed corn? Give specific data to substantiate your statement.

8. What are the important factors in increasing the corn yield?

9. Why does the rotation of crops help to increase yields?

10. Why is corn so generally grown?

11. Discuss the uses of corn.

PROBLEMS

1. Compare the feeding value of corn with that of wheat. Also corn silage and red clover hay.

2. Compare the yields of corn, wheat, oats and any other crop in amount and money value.

REFERENCES

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Hunt, Cereals in America.
Wilson and Warburton, Field Crops.
Gehrs, Productive Agriculture.
Bowman and Crossley, Corn.

CHAPTER IV

OATS

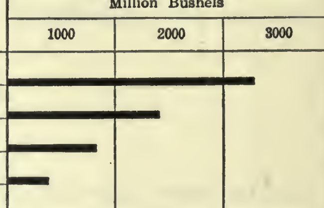
History of oats. — From the best data available, it seems that oats are native to eastern Europe and possibly to Tartary in western Asia. Wheat and barley, having been used by the ancient Egyptians, Hebrews, Greeks and Romans, antedate oats. Oats were first domesticated about the beginning of the Christian era, and their culture up to the discovery of America was confined almost wholly to the temperate regions of Europe.

The growing of oats was relatively unimportant until western and northern Europe became civilized. Then the expansion of oat cultivation and its improvement really began. Another epoch in the history of oats began when the crop was introduced into America. It has spread with the expansion of the people of the United States, and to-day the culture of oats is coextensive with civilization itself.

Importance of the oat crop. — The oat crop ranks second in the United States in number of bushels produced. The following graph shows the relative importance of five of the leading crops in the United States:

YIELD OF CROPS 1914-1918 INCLUSIVE

Crop	Average Yield 1911-1918	Weight per Bushel	Number of Bushels	Million Bushels		
				1000	2000	3000
Corn	25.7	56	2,279,700,000			
Oats	33.7	32	1,415,600,000			
Wheat	15.1	60	822,088,000			
Potatoes	96.6	60	379,460,000			
Barley	26.7	48	174,570,000			



[1] U. S. Yearbooks of Agriculture.

Oats in 1918 produced more pounds of food than any other crop except corn, exclusive of 30 per cent loss for hull. In 1917, according to the Report of the Food Administration, only 3 per cent of the entire crop was directly consumed by man. The rest was used as feed. About one-fourteenth of the entire improved farm acreage in the United States is devoted to oat production.

The North Central States are the principal oat producing states. The following graph shows the leading states in oat production:[1]

Oat-producing States in Bushels and Per Cent of Crop Produced by Each State

	Bushels	Per cent (0%, 5%, 10%, 15%)
United States	1,416,600,000	
Iowa	207,127,000	14.5%
Illinois	186,214,000	13.1%
Minnesota	112,544,000	7.9%
Wisconsin	90,062,000	6.3%
Nebraska	78,306,000	5.5%
Indiana	66,600,000	4.7%
South Dakota	66,000,000	4.6%
Ohio	65,000,000	4.5%
North Dakota	63,160,000	4.4%
Michigan	52,000,000	8.7%
Kansas	51,400,000	3.6%
Missouri	38,640,000	2.8 %
Rest of the United States		24.4%

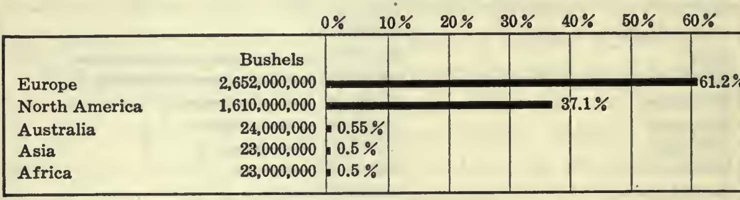
Iowa, Illinois and Minnesota produce about one-third of the entire oat crop of the United States. The graph shows that the oat crop is grown mostly in the states which have a cool, moist climate.

Adaptability of oats. — Oats thrive in a cool, moist climate. They grow farther north than corn and require more moisture to mature them. Oats require, according to King, of the Wisconsin Station, 522 pounds of water to mature one pound of dry matter, while corn requires only 310 pounds. As evidence of the fact that oats grow best in rather cool conditions, the graph on page 80 is given.[2]

[1] U. S. Yearbooks 1914–1918 inclusive. [2] U. S. Yearbooks 1911–1915 inclusive.

When we recall that the oat regions of Europe are north of 45 degrees and that the oat producing states of the United States are north of the 30th parallel, we can readily see that a cool temperature is best suited for oat production. Ninety-eight per cent of the oat crop is grown in Europe and North America. The oat producing nations in the order of production are: the United States, Russia, Germany, France, Austria-Hungary and the United Kingdom. All the oat producing countries and states receive a liberal supply of rainfall.

Distribution of Oat Production in Bushels Produced by the Grand Divisions of the World



We have emphasized the importance of cool, moist conditions for oat production because farmers may incorporate cooler days into the growing season by sowing earlier, and they may control the moisture supply to a considerable extent by culture.

Economic aspects of oat production. — The cost of oat production is an important item in connection with this topic. The Bureau of Statistics of the United States Department of Agriculture,[1] through the data sent them by about 5000 farmers from all over the United States, calculated the average cost of an acre of oats in the United States. The items were distributed as follows:

	Average
1. Rent	$ 3.78
2. Preparation of land	1.88
3. Threshing, grading, etc.	1.51
4. Harvesting	1.34
5. Seed	1.12
6. Miscellaneous, fertilizers, seeding	1.38
Total	$11.01

[1] Crop Reporter, June, 1911.

The cost of acreage production cannot change greatly except as different amounts of work are devoted to production; but the cost of bushel production varies almost directly according to the number of bushels produced per acre. An oat yield of 30 bushels costs almost twice as much per bushel as a yield of 60 bushels. Therefore, the factors causing low yields should be known in order that the farmer may guard against them.

Improvement of oats. — The qualities a good oat should possess are as follows: (1) Tillering or stooling ability; (2) High percentage of kernels; (3) Weightiness; (4) Stiffness of straw; (5) Resistance to rust; (6) Early maturity.

Even within the same variety some kernels have a much higher capacity to *stool* or put out additional stems than others. Although the large factor in producing stooling is cool, moist weather, the farmer may improve the yield by selecting seed from those stems that show a tendency to stool.

A high percentage of kernels is essential to yields. Some oat stems will bear 30 kernels, some 60, and others 90 or more. Only the prolific kinds are worthy of perpetuation. Poor producers should be eliminated.

Weightiness gives oats their quality as far as real feeding substance is concerned. In most states the standard weight of oats is 32 pounds to the measured bushel. Seed oats should weigh more, for more weight indicates less hull and more kernel. A good oat will have as little as 30 per cent hull and 70 per cent or more kernel.

Stiffness of straw, also, varies to some extent in oats of the same variety. There is a great deal of loss in oat production due to lodging. This may be overcome by selecting those varieties having stems that are stiff.

The rusts do untold damage to oats, and will be discussed in a later paragraph.

Earliness is a quality sought in oats, because early oats are freed to a large extent from storms, insect and fungous enemies, and hot, dry weather. The number of days from planting time

to maturity of 36 varieties at the Ohio Station (Bul. No. 257), ranged from 94 to 112 days.

Factors aiding oat yields. — The factors aiding oat yields are: (1) Proper preparation of the seed bed; (2) Use of heavy seed; (3) Treating seed oats for smut; (4) Shallow sowing; (5) Drilling oats; (6) Early sowing; (7) Proper rotation of crops; (8) Use of prolific varieties; (9) Use of barnyard manures; (10) Use of commercial fertilizers; (11) Combating the enemies of oats; and (12) Harvesting properly.

1. Seed Bed and Oat Yields. *Proper preparation of the seed bed* is an important factor in increasing oat yields. Oats prefer a soil that is mellow, friable and firm, from three to five inches deep. Since loam and clay loams have a greater capacity for holding water than sand, they are better adapted for oat production. Sandy soils are too dry for oat production, and compact clays are too wet and cold. Although oats will yield better than either corn or wheat in a poorly prepared seed bed, careful preparation of the seed bed will be amply repaid by increased production.

Fall plowing probably has advantages over spring plowing because it permits the soil to warm and dry out more rapidly, and thus the oat crop may be sown earlier, an important factor in securing yields. At the Oklahoma Station,[1] fall plowed land yielded 34.8 bushels, and spring plowed 32.0; at the Michigan Station,[2] fall plowed land yielded 49.6 bushels, and spring plowed 42.0 bushels; at the North Dakota Station,[3] fall plowed land yielded 28.6 bushels, and spring plowed 26.0. In other experiments spring plowed soils have yielded almost as well, and sometimes better, than fall plowed soils. Fall plowing may be recommended, for it has the advantages above indicated and facilitates work in the spring.

2. *The size of seed* has an influence on oat yields. Seed oats should be carefully screened and graded before sowing. All light oats, oats without kernels in them and pin oats should be

[1] Bulletin No. 16. [2] Bulletin No. 164. [3] Bulletin No. 11.

excluded from the seed by a fanning mill. The small oats, many of them, will not germinate at all, and those that grow produce a small, unproductive stem. Since large, heavy seeds are less numerous per bushel than small seeds, slightly more should be sown per acre. Experiments using heavy, common and light seed[1] gave the following results.

HEAVY SEED VS. LIGHT SEED AND YIELDS

	Kansas Station, 8-Year Test	Ohio Station 7-Year Test	Ontario Station, 7-Year Test	Average of All Stations
Heavy seed oats . .	30.9 bushels	46.3 bushels	62.0 bushels	49.4 bushels
Common seed oats .	29.9 bushels	44.8 bushels	54.1 bushels	42.9 bushels
Light seed oats . .	27.5 bushels	42.6 bushels	46.6 bushels	38.9 bushels

From these experiments it may be observed that heavy seed oats yielded 6.5 bushels more to the acre than common seed, and 10.5 bushels more than light seed.

At the Minnesota Station[2] two bushels each of oats were sown, weighing 37 and 21 pounds respectively. The yield from the heavy seed was 64 bushels per acre; and from the light seed 55 bushels per acre.

Bailey's Cyclopedia, Vol. II, states: "Zavits, of the Ontario Agricultural Experiment Station, conducted an 11 year experiment to determine the effect of constant selection and sowing of heavy, plump grains in contrast to light grains. He found at the end of 11 years the yield from the former was 77 bushels, and from the latter 58 bushels per acre. Professor Zavits expressed the belief that oats could easily be increased 15 per cent by careful selection of seed."

The selection of seed oats is worthy of the close consideration of the farmer, for the additional yield accruing from the use of heavy seed oats is almost pure profit — except it costs a little

[1] U. S. Bulletin No. 424. [2] Bulletin No. 31.

more to harvest and thresh. The yield of oat straw is also slightly increased by the use of heavy seed.

3. *Treating seed oats for smut* combats one of the greatest enemies of the crop. From conservative estimates,[1] there is a 3 per cent annual loss from loose smut. It amounts to about 27,000,000 bushels of oats, which at 40¢ per bushel are worth about $11,000,000. The loose smut attacks the entire oat head and turns it into spores. Loose smut can be controlled by the formalin treatment described in connection with the chapter on wheat, or by submerging the sack containing the seed oats in the formalin solution for 10 minutes. The oats should be then dried before sowing so that they will readily pass through the drill.

FIG. 37. — Covered with loose smut of oats.

4. *Depth of sowing* affects to some extent oat production. Practically all experiments favor shallow seeding. Best results have been secured with sowing from one to two inches.

"Most of the experiments favor shallow seeding. At the Ohio Station the average of two years' results showed a yield of 3.56 bushels to the acre greater for the 1-inch than for the 2-inch depth, and 7.73 bushels to the acre greater for the 1-inch than for the 3-inch or the 4-inch depth. Covering only 1 inch deep gave better results at the Illinois Station than sowing at greater depths." [2]

5. *Drilling oats* helps in increasing the yield. This is especially true if oats are sown in the fall in well-prepared soil. However,

[1] Farmer's Bulletin No. 424, U. S. Department of Agriculture.

[2] Farmer's Bulletin No. 424.

in some cases, broadcast seeding has resulted in better yields. Drilled oats at the Illinois Station in a three years' test yielded 5.3 bushels more per acre than broadcast seeding.

DRILLED VS. BROADCASTING OATS

	DRILLED BUSHELS	BROADCAST SEEDING BUSHELS	BUSHEL INCREASE	PERCENTAGE INCREASE DUE TO DRILLING
Kansas Station 7-year test[1]	30.0	26.24	3.76	14
Nebraska Station 4-year test[2] . . .	40.1	31.4	8.7	27

Drilling oats has the following advantages: (1) Seed is evenly distributed; (2) Seed is covered at a uniform depth; (3) Less seed is necessary; (4) Seed germinates more uniformly; (5) Growth is more uniform, and the oat will mature more evenly at the same time; (6) Usually a larger yield is secured.

FIG. 38. — Seeding oats with a drill helps to increase oat yields.

6. *Time of sowing* is *one* cf the most important factors in securing a good yield. In the South, oats are sown in the fall; in the North, in the spring. Bulletin 424, U. S. Department of Agriculture, says: "One of the greatest essentials in growing oats is to get the seed into the ground early. The crop grows best in cool climates and in cool weather, and is often materially injured by a few hot days when it is near maturity. Frosts or even hard freezes after the seed is sown seldom injure it, so that as a rule oats should be sown just as soon as the ground is in condition to work in the spring."

[1] Kansas Bulletin No. 424. [2] Nebraska Station Bulletin No. 135.

A few experimental records are here included, to show the relation of time of seeding to oat production.

EARLY SOWING INCREASES OAT YIELDS

VIRGINIA STATION FOUR YEARS' TEST	
Sown Sept. 15	30.64 bu.
Sown Sept. 30	28.06 bu.
Sown Oct. 15	15.32 bu.

OHIO STATION THREE YEARS' TEST	
Sown March 22	69.11 bu.
Sown April 1 to 13	64.09 bu.
Sown April 14 to 27	55.55 bu.

[1] Ohio Station Bulletin No. 257.

Sown Sept. 15. Yield 30 bushels.

Sown Oct. 15. Yield 15 bushels.

FIG. 39. — The above illustrates the relation of time of seeding to oat production in Virginia.

7. *Rotation of crops* aids in keeping up and helping to increase oat yields. Corn, oats, wheat is a common rotation in the corn belt states. Clover and timothy are occasionally grown two years, making a five-year instead of a three-year rotation. Oats is less influenced in a rotation than corn or wheat. However, at the College of Agriculture, University of Missouri, the following results were secured.

ROTATION HELPS TO INCREA E OAT YIELDS

Average Yields for 25 Years	
Continuous oats	14.52 bushels
4-year rotation, corn, wheat, oats, clover	27.30 bushels

It will be noted that the oat yield in the rotation was almost twice as much as it was in the place where it was grown continuously.

8. *Use of prolific varieties.* — The following table is given to show how oat varieties differ in productiveness. Similar data are in possession of almost every experiment station of the world.

VARIATIONS OF PRODUCTIVENESS OF DIFFERENT VARIETIES OF OATS [1]

	1904 Bu.	1905 Bu.	1906 Bu.	1907 Bu.	1908 Bu.	Average Bu.
Lincoln	50.7	24.3	42.2	14.1	17.6	29.78
Swedish Select	70.0	45.3	61.6	24.1	25.0	45.2
Wide Awake No. 154 . . .	51.7	24.1	35.0	11.9	12.5	27.04
White Schoenen No. 153 . .	46.8	20.6	19.4	00.0	8.4	23.80

Swedish Select at the South Dakota Station yielded about 22 bushels per acre more than did White Schoenen No. 153 in the above 5 years' test.

No hard and fast rule can be indicated regarding the use of a variety of oats for any section of the United States, nor for any state, because soils and climate vary greatly even within a state.

[1] Bureau of Plant Industry, Bulletin No. 182, S. D. Exp. Sta. Record.

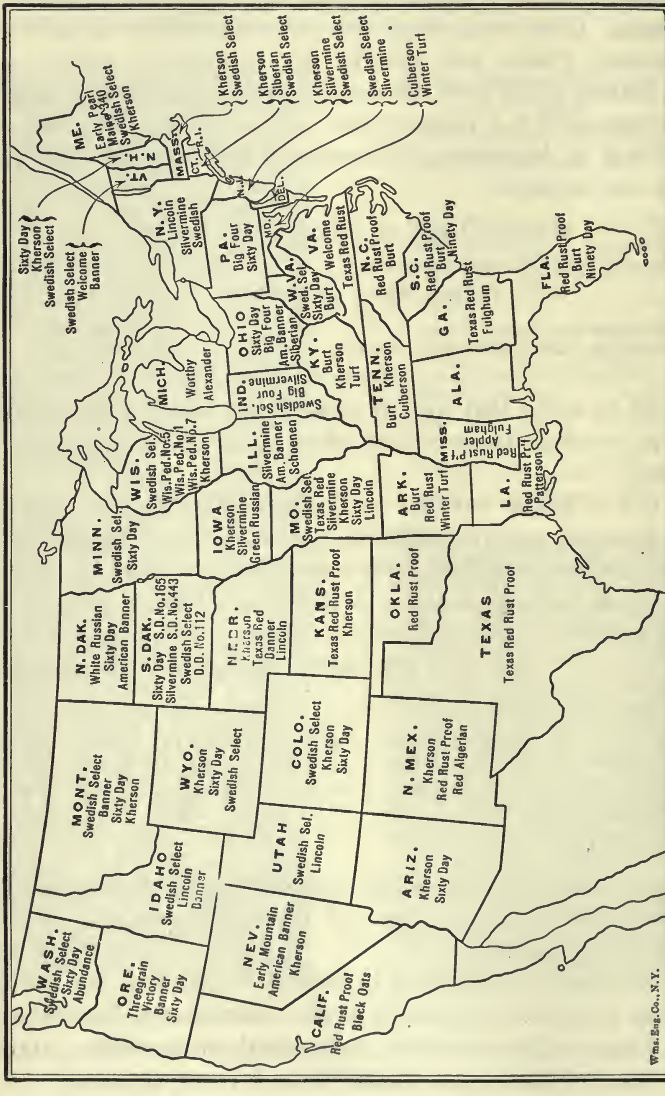


FIG. 40. — Some of the varieties of oats recommended by your state experiment station for your state.

However, the map on page 88 [1] indicates the varieties recommended for the different sections of the United States and for each state.

Kherson oats, introduced from Russia into the United States by the Nebraska Station in 1896, deserve a separate paragraph, for they are widely distributed and are yielding well. The United States Yearbook of Agriculture, 1916, says: "Two new lines of Kherson oats have been developed in coöperation with the Iowa Agricultural Experiment station and have been widely distributed through Iowa and adjoining states. A large number of tests by farmers have shown a ten per cent increase in yield over the varieties previously grown. Their use for the entire oat acreage of Iowa probably would result in an increase in production in that state alone of from 12 to 15 million bushels."

9. *Barnyard manure*, although not usually applied to the oat, can be profitably utilized in oat production. Barnyard manure contains nitrogen, phosphorus, and potash, the elements most frequently lacking in the soil, and also supplies organic matter.

Instances could be cited that would show distinct gains in manuring for oat production; on the other hand, instances are on record showing that manuring oats caused distinct losses in oat yields — the latter being due to a rank growth, causing the oats to lodge.

10. *Commercial fertilizers* may be used in oat production to good advantage. Warburton, in Farmer's Bulletin No. 424, says: "Of the three elements, — nitrogen, phosphorus, and potash, — phosphorus is most often the one which is not present in sufficient quantities for the best production of oats. This is particularly true in certain types of prairie soils in the Upper Mississippi Valley." Phosphoric acid hastens ripening and helps fill the grain, thereby increasing the weight and quality. Potash helps plump the kernel, strengthens the straw, and prevents lodging. Consequently, if commercial fertilizers are applied to oats, those containing the ingredients of phosphorus in a larger amount,

[1] Farmer's Bulletin No. 424, U. S. Department of Agriculture.

potash to a smaller degree and nitrogen in still smaller quantity are recommended. If the oat crop is desired for forage, the use of a fertilizer high in nitrogen should be applied, for nitrogen induces a ranker growth.

11. *Combating enemies of oats is an important item in oat production.* — The fungous enemies of oats are smut and rusts. How to control smut has been explained in a previous paragraph and need not be further discussed.

Rusts are of two kinds, — leaf rust and stem rust. The latter does the most damage, for it sucks from the stem the plant foods that should go to the oat panicle and the grain. No accurate statement as to the extent of reduced oat yield can be made, but rusts often cause enormous losses in the crop. As there are no direct means of reducing the bad effects of rust, only preventive measures can be used. Some of these are as follows: (1) Early sowing; (2) Drilling oats; (3) Sowing an early maturing variety; and (4) The use of rust resistant varieties.

Insects, especially the chinch bug, are not so harmful to the oat crop as they are to wheat, rye and barley. The best preventive of chinch bugs is burning them in their winter quarters. They hibernate in fence corners, grass, leaves, etc. For further treatment see the chapter on Wheat.

12. *Timely harvesting helps in increasing the food value and worth of the oat crop.* — Production is half; harvesting and feeding the crop is the other half. Oats are cut when they have just passed from the milk stage into what is called the hard dough stage, or just a very little later. The heads have turned yellow and the leaves are also beginning to turn. If cut earlier the kernels shrivel and become lighter. However, the straw of oats may cure slightly better when cut a little earlier. Harvesting overripe oats causes some loss, due to shattering at cutting as well as at threshing time.

Oats, when cut, should be shocked immediately, for exposure to the sun bleaches the straw and the grain and reduces the quality of both. Oat shocks should usually be smaller than wheat shocks

for the reason that oat straw contains more moisture. The shocks should be carefully capped to protect the oats as much as possible from dews, rains and sunshine.

While threshing out of the shock is a very common practice, and while this is quite satisfactory if the season is dry and the threshing crew may be had at the time when the oats are in proper condition for threshing, stacking oats may be recommended as good farm practice. It is estimated that it costs about one cent per bushel more to stack and thresh oats than to thresh them out of the shock, but as a rule a better quality of grain is secured by stacking. Oats, like wheat, go through a sweating process both in the shock and in the stack. Each process takes from 3 to 5 weeks. Oats should not be threshed until they have passed through these sweating processes.

The oat straw should either be put into a barn, or be well stacked. Oat straw is worth from $3.00 to $6.00 per ton as a feed; hence it should be carefully guarded. Its composition and feeding value will be mentioned in a following paragraph.

Uses of oats. — Oats are generally fed on the farms where produced. It is probably safe to say that at least $\frac{3}{4}$ of the crop is so fed. The following statement from Farmer's Bulletin 420 indicates the percentage shipped out of the locality in which it is produced:

1901 — 19.5 per cent — smallest ever shipped out of country where grown.
1909 — 32.7 per cent — largest ever shipped out of country where grown.

Oats are well adapted as a feed for work horses. They are muscle building instead of heat producing, like corn. For this reason oats are used to a greater extent for work horses in summer. Oats are said to be the safest of horse feeds, for the hull gives bulk to the feed, so that horses do not gorge themselves. Dairy cattle, fattening sheep, and beef cattle do splendidly on a part oat ration.

It is the plump kernel, however, that counts in feeding. If in feeding 100 pounds of oats, 40 pounds are hulls, the feeding

value is greatly reduced over a quality of oats, 30 per cent hull to kernel. Shelled oats contain about 70 per cent kernel and 30 per cent hull, and weigh 32 pounds to the measured bushel. Clipped oats have the pointed end of the hull clipped off, and weigh 45 pounds to the measured bushel.

Oats have the following digestible composition per 100 pounds. Wheat and corn are given for comparison.

PERCENTAGE DIGESTIBLE COMPOSITION — OATS, ETC.

	Total Dry Matter	Crude Protein	Carbohydrates	Fat	Total	Nutritive Ratio	Therms in 100 Lb.
Wheat . .	89.8	9.2	67.5	1.5	80.1	1 : 7.7	82.63
Corn . . .	89.5	7.5	67.8	4.6	85.7	1 : 10.4	88.84
Oats . . .	90.8	9.7	52.1	3.8	70.4	1 : 6.3	66.27
Oatmeal .	92.1	12.8	56.9	6.0	83.2	1 : 5.5	74.00
Oat straw .	88.5	1.0	42.6	0.9	45.6	1 : 44.6	22.21

Wheat has 80 pounds of digestible material in 100 pounds, oats have 70. According to this, oats have $\frac{7}{8}$ of the feeding value of wheat. But, since the nutritive ratio of oats is as 1 : 6.3 and that of wheat is as 1 : 7.7, oats have a relatively higher per cent of protein, a very desirable thing in a feed. The heating value of wheat is 82 therms per hundred pounds and of oats it is 66. This indicates that oats have a little more than $\frac{3}{4}$ of the heating value of wheat.

On the worth of oats as a human food we repeat a story found in Hunt's book entitled *Cereals in America:* "The witty Dr. Johnson sarcastically remarked, 'Oats is a grain fed to horses in England but eaten by men in Scotland.' 'Yes,' said the Scotchman, 'and I have noticed that they grow the best of horses in England and the best of men in Scotland!'"

Summary. — Oats are native to eastern Europe and southwestern Asia. The crop is adaptable to cool, moist conditions and is chiefly grown in the temperate regions. It ranks high in comparison with corn and wheat in both acreage and bushels produced.

The North Central States constitute the oat region of the United States. A good quality oat plant must possess the following characteristics: (1) Must be prolific in tillering; (2) Yield a high percentage of kernels; (3) Be weighty; (4) Have a stiff straw; (5) Be rust resistant; and (6) Mature early.

The factors aiding oat yields are: (1) Proper preparation of seed bed; (2) Size of seed sown; (3) Treating seed oats for smut; (4) Depth of sowing; (5) Drilling oats; (6) Early sowing; (7) Proper rotation of crops; (8) Use of prolific varieties: (9) Harvesting properly; (10) Use of barnyard manure; (11) Use of commercial fertilizer; and (12) Combating the enemies of oats.

Oats are used mostly upon the farms where they are produced, and fed almost wholly to live stock. About 3 per cent of the 1917 oat crop was used as human food. Oats are the finest of horse feeds.

QUESTIONS

1. Briefly narrate the history of oats.
2. What is the importance of oats compared with other farm crops?
3. Where is the oat crop mainly grown, and why?
4. What are the qualities of a good oat?
5. What are the factors essential for oat yields?
6. What are the chief enemies of oats? How may each be combated?
7. Who is the best oat producer of your locality, and why?

PROBLEMS

1. Compare the food value of oatmeal with 5 common foods.

2. State the exact oat acreage and yield of all the states of the United States for last year.

3. Give the acreage and yields of the grand divisions of the world. Of the leading oat producing nations.

REFERENCES

Wilson and Warburton, Field Crops.
Livingston, Field Crop Production.
Hunt, Cereals in America.
Bailey's Cyclopædia, Vol. II.

CHAPTER V

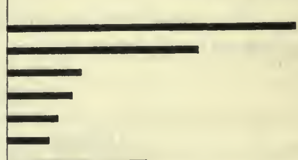
POTATOES

History. — The potato, also called white potato, round potato and sometimes the Irish potato, is of American origin. It is native to the elevated valleys of Peru, Chile and Mexico. Some of the wild forms of the potato have been found in Arizona and Colorado. It is thought that the potato has been grown in these countries for 2000 years or more. De la Vega found potatoes growing in Peru in 1542 and sent some to Spain. The Spanish found them to be a good crop and imported them to a considerable extent. Potatoes were introduced into Ireland in 1586. The English colonists secured potatoes through trade from the Spanish. They soon proved a valuable product to the colonists. Now they are grown the world over. Circular 39 of the United States Department of Agriculture states, "In normal times the potato contributes 13 per cent of our food material and serves as a bread supplement and substitute." In European countries the potato constitutes about 25 per cent of the diet of the people.

Distribution of the potato. — The production of potatoes in the world and in some of the leading potato producing nations for 1913 is given below. No data are available for any later period covering all the countries, but that year's production may be taken as representative.

Potato Production in the World and Leading Potato Producing Nations [1]

	Bushels
World	5,802,910,000
Germany	1,988,591,000
Russia	1,307,606,000
France	499,000,000
Austria	424,459,000
United States	331,525,000
United Kingdom	283,912,000
Rest of the World	968,782,000



[1] U. S. Department of Agriculture.

From the above data it may be seen that Germany and Russia produce more than half of the potatoes of the world. It will also be seen that the United States produced about 3.31 bushels per person at that time.

The production in the United States for 1917 was 442,536,000 bushels.[1] The leading potato states for 1918 were as follows:

	Bushels	0% 2% 4% 6% 8%
United States	400,106,000	
New York	34,960,000	8.7%
Wisconsin	33,040,000	8.2%
Minnesota	32,720,000	8.1%
Michigan	28,560,000	7.1%
Pennsylvania	24,400,000	6.0%
Maine	22,400,000	5.4%
California	12,870,000	3.1%
Virginia	11,750,000	2.9%
Illinois	11,520,000	2.8%
Colorado	11,376,000	2.7%
Nebraska	10,400,000	2.5%
Iowa	9,648,000	2.4%
Rest of the United States		40.1%

The 1918 potato crop of the United States yielded about 4.0 bushels of potatoes per person. The average consumption in the United States is about 2.5 bushels exclusive of seed potatoes. The consumption per person increased during the war. The distribution of the potato crop for 1917 is shown in the map on page 96.

Advantages of potato production. — 1. The great advantage of the potato is that it may be grown on almost any type of soil, and hence any gardener may grow the crop. It is for this reason that potatoes are found in almost every garden in the United States. Of course, for commercial purposes climates and soils are selected that produce the crop most abundantly and economically, as is shown in the following map.

[1] U. S. Yearbook of Agriculture.

2. Potatoes have the advantage of yielding a large amount of human food per acre. This is shown in the following table, based

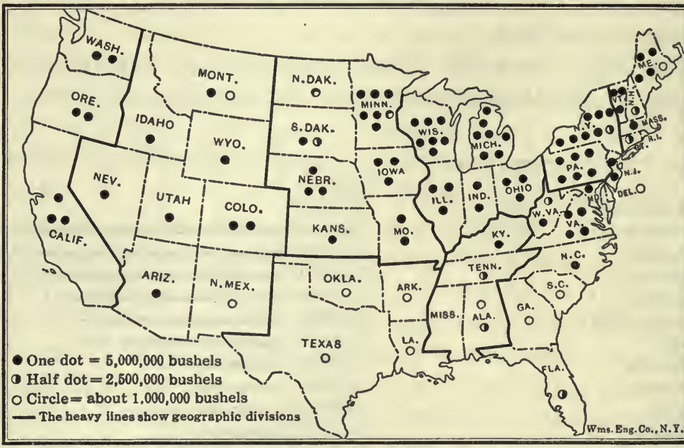


FIG. 41. — Map to show distribution of potato production in 1917.

upon average yields, counting 60 pounds per bushel for wheat and potatoes and 56 for corn.

COMPARATIVE YIELDS OF POTATOES, WHEAT AND CORN PER ACRE

	Average Yields U. S. 1907–1916	Dry Matter (Pounds)	Fat (Pounds)	Crude Protein (Pounds)	Ash (Pounds)	Carbo-hydrates (Pounds)	Calorific Value[1]
Potatoes	95.4 bu.	1242	6.0	102	14	842.0	1,813,000
Wheat .	14.7 bu.	782	18.0	109	17	647.0	1,450,000
Corn . .	26.0 bu.	1203	74.0	147	22	1062.0	2,405,000

It will be observed that potatoes compare well with wheat in all the nutrients, and that their heat producing capacity per acre is slightly higher than that of wheat.

[1] The calorie is the unit of heat, and is the amount of heat required to raise the temperature of one kilogram (2.2 pounds) of water 1° C. or one pound of water nearly 4° Fahr.

3. Potatoes do not require any technical machinery to prepare them for human use. They may be used as soon as matured. This makes the potato a very convenient and economical food.

4. Potatoes, because of their high starch content, take the place of wheat. Four bushels of potatoes are counted the equivalent of one bushel of wheat for food. The potato has the following digestible composition:

PERCENTAGE DIGESTIBLE COMPOSITION OF POTATOES, WHEAT AND MILK

	DRY MATTER	CRUDE PROTEIN	CARBOHYDRATES	FAT	NUTRITIVE RATIO
Potatoes	21.2	1.1	15.8	0.1	1 : 14.5
Wheat	89.8	9.2	67.5	1.5	1 : 7.7
Milk	13.6	3.3	4.9	4.3	1 : 4.4

Potatoes compare well with milk as a food, except that they lack in protein, and the mineral matter in not quite so well balanced.

5. Potatoes make a good feed for hogs. In the potato regions small potatoes are used for this purpose.

Qualities a potato should possess. — Potatoes should possess the following qualities: (1) They should be prolific yielders; (2) They should be of a good size and shape — firm, medium sized potatoes are preferred; (3) Potatoes must possess good cooking qualities and have a good flavor; (4) Smooth potatoes having few and comparatively shallow eyes are desired by the market; (5) Resistance to disease is an important feature of potatoes — some varieties and strains within the variety are more resistant to disease than others; (6) Time required for maturity is an important consideration — in some sections early maturing varieties are desired, in other sections the reverse quality is preferred; and (7) The potato should be true to type in shape, color, peeling and flavor. Seed potatoes should be carefully purchased and then improved from year to year by selection.

Courtesy Farmer's Bulletin.

FIG. 42. — Strong tuber units of the Gold Coin variety of potatoes.

Courtesy Farmer's Bulletin.

FIG. 43. — Weak tuber units of the Gold Coin variety of potatoes. Compare the yield shown with Fig. 42.

Factors aiding potato production. — The principal factors aiding potato production are: (1) Seed selection; (2) Sprouting seed potatoes; (3) Use of prolific varieties; (4) Use of a proper amount of seed; (5) Fertile soils; (6) Good culture; (7) Use of fertilizers; (8) Control of insects; (9) Control of potato diseases; and (10) Scientific harvesting and storing. Each factor of production will be discussed in a general way and substantiated with such specific evidence as is available.

1. *Seed selection.* — Every grower of potatoes knows that some hills produce two or three times as much in weight as other hills which have had the same soil, culture, sunshine and rain. This variation in production is due to inherent qualities of prolificacy. At the Cornell Experiment Station[1] the following results were obtained in a five years' test of low and high producing strains. The high yielding strains produced 823 bushels per acre, while the low yielding produced an average of 207.3 bushels per acre.

Waid, at the Ohio Station,[2] compared productive plants with those from unselected stock and from low yielding plants. With 100 hills of each the average yield for three years was as follows:

High yielding seed	138 pounds
Unselected seed	110 pounds
Low yielding seed	73 pounds

The gain of the high yielding over the unselected plants was 25 per cent, and over the low yielding more than 90 per cent.

The preceding figures, photographs of the Gold Coin variety, illustrate the comparison of high yielding and low yielding plants.[3] The average yield for these plants for 1911 and 1912 was as follows:

Strong Plants	Weak Plants
3.2 pounds of prime	0.2 pound of prime
1.77 pounds of culls	0.68 pound of culls
4.97	0.88

From the above data it may be seen that it pays to select seed potatoes from prolific plants. It increases production and reduces the cost.

[1] Plant Breeding Series No. 3. [2] Bulletin No. 174. [3] Farmer's Bulletin No. 533.

2. *Sprouting seeds* increases potato yields because the plants have from two to three weeks start over potatoes not sprouted. Seeds that are kept in cold storage up to the time of planting do not start to grow for about ten to fifteen days. Seeds are sprouted by placing them in a warm lighted place for three or four weeks

Courtesy Penn. Station.

FIG. 44. — On the left tubers sprouted in the light, — in good condition for planting by hand. The sprouts are too long for a planter. On the right the tubers are sprouted too much, and are in poor condition for seed.

before planting. During this period the buds get a good start. The buds should not be permitted to get too long. The growth can be checked by placing the potatoes in a cool place.

At the Rhode Island Station[1] the influence of sprouted seeds upon yield is shown in the following table:

	Date of Planting	Date of Harvesting	Yield per Acre		Total Bushels	Gain by Sprouting Bushels
			Large Tubers Bushel	Small Tubers Bushel		
Sprouted	May 1	July 29	89.0	53.0	142	23
Not sprouted	"	"	76.0	43.0	119	
Sprouted	May 1	Aug. 20	135 0	55.0	190	54
Not sprouted	"	"	94 0	42 0	136	

[1] Bulletin No. 36.

It will be observed that the sprouted potatoes yielded 23 and 54 bushels more than the unsprouted. The above are representative data.

3. *The use of prolific varieties.* — At the Ohio Station over a five year period, in rows 35 feet long, the five best yielders produced on an average of 38.7 pounds, while the five poorest varieties yielded 30.7 pounds to the row.[1] Similar data may be had from almost all the experiment stations. The following varieties are recommended for the respective states by the Chief Agronomist of each state. These are recommendations which apply in a general way. For any particular type of soil and locality the conditions may be different. It is best to write your station.

State	Varieties of Potatoes Recommended
Alabama . . .	Bliss Triumph, Irish Cobbler
Alaska	Irish Cobbler, Golden Coin, Burpee's Surprise
Arizona . . .	Early Ohio, Irish Cobbler
Arkansas . . .	Early Ohio, Six Weeks, Red Bliss
California . .	Burbank, British Queen, Early Ohio, Garnet
Colorado . . .	Rural Pearl, Peach Blow, Early Ohio
Connecticut . .	Cobbler, Snow Green Mountain
Delaware . . .	Irish Cobbler, Sir Walter Raleigh, Green Mountain
Florida . . .	Bliss Triumph, Spalding Rose
Georgia . . .	Irish Cobbler, Bliss Triumph, Lookout Mountain
Idaho	Early Ohio, Irish Cobbler, Golden Coin
Illinois	Early Ohio, Irish Cobbler
Indiana . . .	Early Ohio, Early Rose, Irish Cobbler
Iowa	Early Ohio, Bliss Triumph, Irish Cobbler, Rural New Yorker
Kansas . . .	Early Ohio, Acme, Irish Cobbler, Bliss Triumph
Kentucky . .	Irish Cobbler, Burbank, Early Ohio
Louisiana . . .	Irish Cobbler, White Star, Burbank
Maine	Green Mountain, Irish Cobbler
Maryland . .	Irish Cobbler, Green Mountain, Carman
Massachusetts .	Irish Cobbler, Green Mountain
Michigan . . .	Early Ohio, Irish Cobbler
Minnesota . .	Irish Cobbler, Burbank, Rural New Yorker
Mississippi . .	Irish Cobbler, and Triumph
Missouri . . .	Early Ohio, Irish Cobbler, Bliss Triumph, Rural New Yorker

[1] Ohio Station Bulletin No. 174.

State	Varieties of Potatoes Recommended
Montana . . .	Early Ohio, Irish Cobbler, Early Rose, Rural New Yorker
Nebraska . . .	Early Ohio, Irish Cobbler, Triumph, White Pearl
Nevada . . .	Burbank, Peerless, Netted Germ, Great Divide
New Hampshire	Green Mountain, Gold Coin, Early Rose, Six Weeks
New Jersey . .	Irish Cobbler, Green Mountain, Gold Coin
New Mexico . .	Rural New Yorker and Irish Cobbler
New York . .	Rural New Yorker, Green Mountain, Irish Cobbler, Early Rose, Early Ohio, Carman
N. Carolina . .	Bliss Triumph, Early Rose
N. Dakota . .	Rural New Yorker, Bliss Triumph, Early Ohio, Burbank
Ohio	Irish Cobbler, Livingston, Early Harvest, Russet
Oklahoma . .	Triumph, Early Ohio
Oregon . . .	Burbank, Carman, Golden Coin, Uncle Sam
Pennsylvania .	Sir Walter Raleigh, Rural New Yorker, Green Mountain
S. Carolina . .	Red Bliss, Irish Cobbler, Triumph
S. Dakota . .	Burbank, Carman No. 3, Rural New Yorker
Tennessee . .	Bliss Triumph, Burbank, Irish Cobbler
Texas	Bliss Triumph, Irish Cobbler
Utah	Idaho Rural, Mortgage Lifter, Pearle, Peerless
Vermont . . .	Green Mountain, Irish Cobbler, Early Rose
Virginia . . .	Irish Cobbler, Early Rose, Sir Walter Raleigh, Carman
Washington . .	Burbank, Irish Cobbler, Netted Germ
W. Virginia . .	Irish Cobbler, Carman No. 3, Rural New Yorker
Wisconsin . .	Triumph, Irish Cobbler, Rural New Yorker, Green Mountain
Wyoming . . .	Rural New Yorker, Triumph, White Ohio, Burbank

A few of the early maturing varieties are: Bliss Triumph, Early Ohio, and Early Rose; medium late maturing varieties are Irish Cobbler, Rural New Yorker, and Burbank. The early maturing potatoes mature in 70 to 90 days; medium, early in 100 to 125 days; and some late varieties in 150 to 200 days.

4. *Use of proper amount of seed.* — Many experiments have been performed to determine the relation of rate of planting to economic potato production. When both yields and profits are considered, the use of from 15 to 20 bushels of seed per acre has given the highest profits. However, when more seed is used, slightly higher yields are secured.[1]

[1] Ohio Station Bulletin No. 218.

At the Ohio Station two varieties, the Bovee and Carman No. 3, were planted two successive years at the rates of 10, 15, 25, and 40 bushels to the acre. When both seed and the crop were valued at 50¢ per bushel, Bovee gave the best returns when 15 bushels were planted, and Carman No. 3 when 25 bushels per acre were planted.

At the Tennessee Station[1] experiments were performed with quantity of seed ranging from 11 to 81 bushels per acre. The highest amount of seed gave the highest yield; but when seed was figured at 75¢ per bushel and the crop at 40¢ per bushel, the planting of 11 bushels of seed per acre gave the greatest return.

The amount of seed used in the South is about 600 pounds per acre. But according to Circular No. 92, U. S. Department of Agriculture, it is considered good practice to plant 900 pounds. The seed should be cut into blocky seed pieces weighing 1 to $1\frac{1}{2}$ ounces, although some authorities recommend the use of slightly larger pieces for seed purposes.

5. *Soils.* — The type of soil is an important factor in getting maximum potato yields, though potatoes will do fairly well in almost all kinds of soils. The soil that is best adapted to potatoes is a deep mellow loam, ranging in texture from a fine sandy or slightly gravelly loam to a silt loam. Such a soil is easy to work and has an early growing condition because it dries out sufficiently to warm up in the spring. The potatoes grown in such a soil come out bright and clean. The loams hold moisture well, which is essential to potato production. It requires from 272 to 497 pounds of water to produce one pound of dry matter. A good potato soil must be well drained, must contain a good supply of organic matter, and must hold its water supply.

6. *Good culture* is an important factor in potato production. The time of breaking the soil affects yields. Fall plowing is recommended because fall plowed soils dry out early in the spring and hence are ready for planting early, a very important factor in securing maximum yields. At the Kansas Station[2] the following yields were secured by plowing at three different times.

[1] Bulletin No. 1, Vol. III. [2] Bulletin No. 194.

When Plowed	Yield per Acre Bushels
March	180
July (preceding Summer)	200
July and March (two breakings)	225

A second plowing is sometimes necessary because of the fact that in some seasons the soil becomes packed. Fall plowed soils usually liberate more plant foods than spring plowed soils.

From six to eight cultivations have given best results, although no definite statement can be given on the number of cultivations because of such wide variations of conditions. Level, shallow cultivations are generally best, especially if the soil has been well prepared. The conservation of moisture in many sections is the principal object in plowing potatoes. Deep and close plowing, such as will prune the potatoes, must always be avoided, for that reduces the thrift and productiveness of the crop.

7. *Use of fertilizers.* — Potatoes require a good supply of humus for best yields. Barnyard manure applied the preceding fall or elsewhere in the rotation is a good practice. When manure is applied directly to the crop, it provides conditions in which the bacteria live that produce potato scab. At the New Hampshire Station[1] 15 tons of manure increased the acreage yield 100 bushels. At the Kansas Station[2] manured soil yielded 142 bushels, while unmanured yielded 120. Barnyard manure adds some plant foods, but its main value in potato production seems to come from the fact that it improves the physical condition of the soil.

Commercial fertilizers applied at the rate of from 150 to 500 pounds per acre often bring economic returns. In some cases more may be applied. At the Ohio Station[3] the average yield of potatoes on unfertilized plots for 15 years was 154 bushels. Eight tons of manure increased the yield 39.31 bushels per acre. And 160 pounds of acid phosphate increased the yield 14.99 bushels, at an increased cost of $1.20. In all cases, according to the above Bulletin, economic returns were secured with a small amount of fertilizer.

[1] Bulletin No. 111. [2] Bulletin No. 194. [3] Bulletin No. 218.

8. *Control of insects.* — The control of the potato beetle is essential to profitable potato production. The loss to potatoes annually from insects and disease amounts to 100,000,000 bushels. This is about 20 per cent of the crop. *The Colorado beetle*, known to all potato growers, is one of the worst enemies of the potato. The bugs should be killed early, for one female lays from 1800 to 1900 eggs.

FIG. 45. — Section of potato plant showing Colorado potato beetle at work.

The potato beetle is easily destroyed by spraying. One pound of arsenate of lead and one pound of soap, added to 25 gallons of water, forms the best spray. See the chapter on the "Control of Insects." Spraying early has many advantages: (1) The bugs are smaller and softer and hence it requires less poison to kill them; (2) The bugs are fewer; and (3) The plants are smaller. It usually takes from 3 to 5 sprays to control the beetles.

9. *Control of potato diseases.* — *Potato Blight* is the most destructive potato disease. The disease is limited to the northern and northwestern section of the United States. Blight appears usually at the blossoming period, and shortens the life of the plant from two to five weeks. And since the last few weeks are the most important as far as the growth of the tubers is concerned, it is important that the blight be combated.

The potato blight is combated by the use of Bordeaux mixture. Spray as soon as the blight appears and every 10 to 14 days thereafter until the potatoes are matured. The leaves of

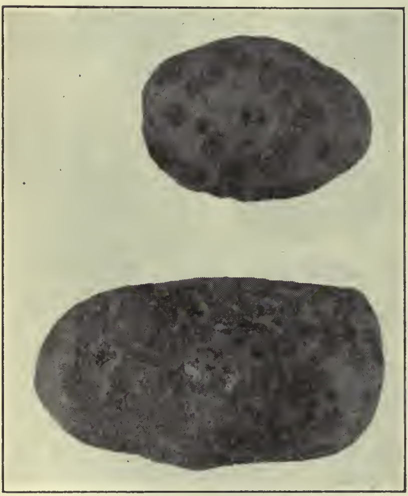
Courtesy U. S. Dept. of Agriculture.

FIG. 46. — Potato leaf showing late blight.

the plants must be kept green, for it is there that the starch which makes the tubers is manufactured. Getting the plants started two weeks earlier by sprouting the seeds and prolonging the green foliage two weeks through spraying are very important

in securing full growth of the tubers. For the making of Bordeaux mixture see chapter on the "Control of Insects."

The value of spraying potatoes is well shown in the following quotation from Farmer's Bulletin No. 868: "The fact that spraying pays has been established by extensive experiments which have been conducted in New York and Vermont. *During a 10-year period at different experiment stations in New York State, an average gain of 60 bushels per acre was secured.* At the Vermont Station, during a 20-year period, which involved all possible seasonal variations, an average gain of 105 bushels per acre, or 64 per cent, over the unsprayed yield resulted."



Courtesy U. S. Dept. of Agriculture.

FIG. 47. — Tubers affected with the common Potato Scab.

Potato Scab is a fungous disease, and is the work of soil bacteria. Planting infected seed potatoes is the chief agency in spreading the disease. An abundance of barnyard manure seems to foster the growth and multiplication of the bacteria.

Potato Scab may be successfully combated by soaking the seed for two hours in a solution of formalin, made by mixing one pint of 40 per cent formalin with 30 gallons of water.

10. *Scientific harvesting and storing* are important factors in securing the maximum results from potatoes. Where there is considerable acreage, potato diggers will lessen the cost of production. Potatoes may be dug with machinery at a cost of two to four cents per bushel, while with hand digging it costs from eight to ten cents per bushel. More potatoes are

injured where potatoes are hand-dug than where they are machine-dug.

Potatoes are stored for the following reasons: (1) Storing serves to preserve a perishable food; (2) It helps to distribute

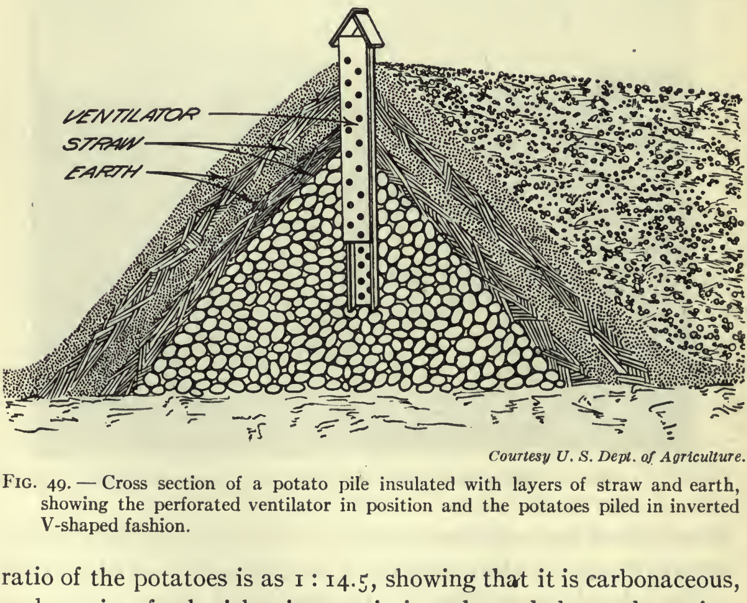
FIG. 48. — A potato digger, saves labor, and reduces the number of injured potatoes.

the supply of an important food; (3) It tends to equalize prices; and (4) Insures the least amount of shrinkage and loss of the crop.

The essential conditions for the storage of potatoes are: (1) Maintenance of a cool uniform temperature — a good storage temperature is 32° to 36° Fahr.; (2) *The storage pile should not be very deep* — perfect aëration is highly important in storing potatoes; (3) The humidity or moisture in the air, also, is a factor to consider in potato storage — there should be sufficient moisture to prevent wilting and not so much that moisture is deposited on the potato.

From 6 to 10 per cent moisture is about the amount lost in 4 to 6 months by the potato under usual methods of storage.

Uses of the potato. — Almost the entire crop is used for human food. A small portion of the crop is used as feed for stock. Potatoes are also used in the manufacture of starch, dextrine, sirup, and alcohol. Potatoes are desiccated. It requires from 3.5 to 4 tons of the raw vegetable to make one ton of dried flakes. Dried potatoes are in good form for transportation. The nutritive



Courtesy U. S. Dept. of Agriculture.

FIG. 49. — Cross section of a potato pile insulated with layers of straw and earth, showing the perforated ventilator in position and the potatoes piled in inverted V-shaped fashion.

ratio of the potatoes is as 1 : 14.5, showing that it is carbonaceous, and requires foods richer in protein in order to balance the ration.

Summary. — Potatoes are of American origin, but Germany and Russia produce about half of the potato crop of the world. The northern and northeastern states are the surplus potato producing states of the United States. The average consumption of potatoes per capita in the United States is about 2.5 bushels exclusive of seed. Four bushels of potatoes is about the equivalent of one bushel of wheat as a food. Potatoes, because of their

high water content, are not extensively transported. The average acreage yield (1907–1916) in the United States was 95.4 bushels; however, in 1917 the average acreage yield was 100.8 bushels.

The factors aiding the production of potatoes are: (1) Seed selection; (2) Seed sprouting; (3) Use of prolific varieties;

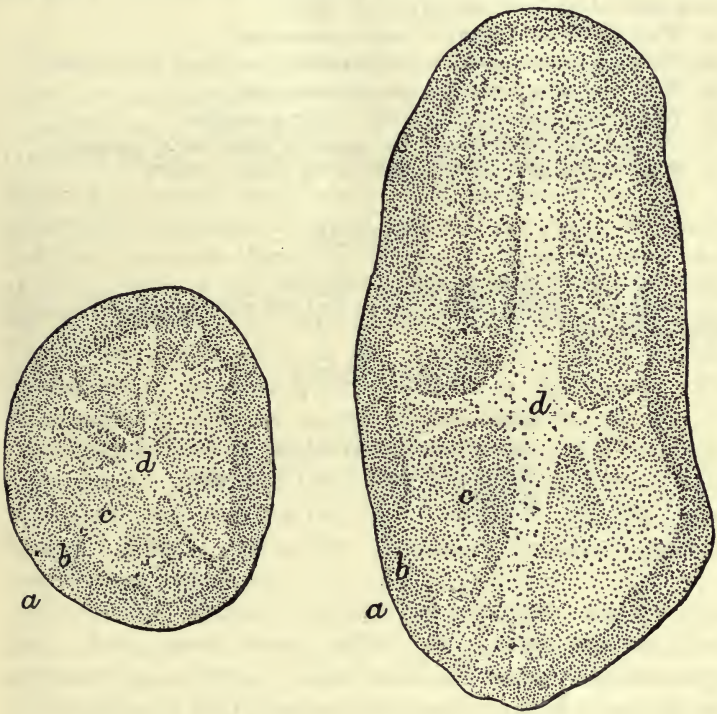


Fig. 50. — Section of potato. (*a*) skin; (*b*) cortical layer; (*c*) outer medullary layer; (*d*) inner medullary layer.

(4) Use of a proper amount of seed; (5) Fertile soils; (6) Good culture; (7) Use of fertilizers; (8) Control of insects; (9) Control of potato diseases; and (10) Harvesting and storing.

The adaptability of the potato, its composition, its being ready

for use as soon as dug, and its abundant yield per acre, indicate that the potato crop is bound to increase in both output and acreage yields.

QUESTIONS

1. Briefly narrate the history of the potato.
2. Compare the importance of the potato yield in the United States with that of corn, wheat, and oats.
3. What are the advantages of potato production?
4. What are the causes of low potato yields?
5. What are the factors aiding potato production?
6. Why keep the potato plant green as long as possible?
7. Compare the composition of 100 pounds of wheat and of potatoes.
8. What are the principal potato producing states? Why?

PROBLEMS

1. Report upon the cost of potato production.
2. Name and discuss all the factors that will tend to reduce the cost of potato production.

REFERENCES

Fraser, The Potato.
Bailey's Cyclopedia, Vol. II.
Wilson and Warburton, Field Crops.
Bulletins.

CHAPTER VI

THE CLOVERS

Cereals and legumes contrasted. — The more important cereals have been considered in preceding chapters. Now we turn to the consideration of the legumes. The cereals belong to the grass family of plants. The grasses have fibrous roots, hollow, jointed stems, and narrow, long leaves. The legumes of the field and garden have long tap roots, their stems are not jointed nor hollow, and their leaves are oblong and trifoliate. Corn, oats and wheat, as well as most of the cereals, are comparatively rich in starches and fats, and hence are carbonaceous. They yield heat energy. The clovers, alfalfa, soy beans and cowpeas are richer in protein in comparison to the cereals, and are therefore nitrogenous. They yield relatively less heat energy, but more physical energy. The cereals as a feed keep animals warm; the legumes give them physical strength. The cereals have the finest fattening qualities among feeds that come from the vegetable kingdom; while the legumes have the power of producing the greatest amount of growth of bone, muscle and tissue.

The leading legumes of agricultural importance are red clover, white clover, sweet clover, alsike clover, crimson clover, alfalfa, soy beans and cowpeas. These useful and important plants engage the attention of the farmer and the people in general and therefore will be considered in the following chapters.

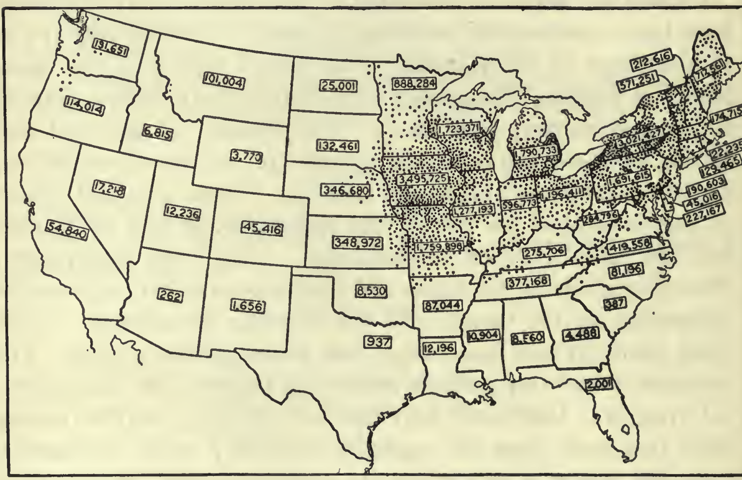
I. *Red Clover*

History. — Red clover, first cultivated about three or four hundred years ago, is a native of Persia and Media. It was domesticated by the countries of western Europe, and was grown

in England as early as 1645. It was extensively grown in Europe in the latter part of the 18th century.

Red clover was introduced into the United States by the English colonists, and was grown in Massachusetts as early as 1747. At the present time it is grown throughout the United States, in Europe, and in some of the South American countries.

Importance and distribution of red clover. — According to the 1910 census report, there were 2,443,000 acres in the United



Courtesy U. S. Dept. of Agriculture.

FIG. 51. — Map of the United States showing the distribution in 1910 of clover and mixed clover and timothy. The figures indicate the number of acres grown in each state.

States in red clover. At the same time red clover was found mixed with timothy meadows to the extent of 19,542,000 acres. The average acreage yield of red clover was 1.29 tons of hay.

Red clover is grown mostly in the northeastern section of the United States. The plant prefers rather moist humid conditions, and a temperature which is rather cool. Red clover does not thrive in the South because of extreme heat, nor in the West because of drought. The preceding map, after the census report of 1910, shows the distribution of the crop.

Advantages of red clover. — Red clover has several advantages: (1) The roots of red clover feed deeper than the grasses and hence tend to rest the surface soil; (2) The deep tap roots of red clover open up the soil and subsoil, and thereby improve the physical condition of the soil; (3) Red clover gathers nitrogen from the soil air and through the bacteria which form nodules on the roots stores nitrogen in the soil; (4) Red clover fits into a system of crop rotation, and tends to check the enemies of other farm crops; and (5) red clover pasture or hay is an excellent feed, being rich in protein and lime. It balances the ration for live stock — and the soil as well.

Courtesy of U. S. Dept. of Agriculture.

FIG. 52. — Young red clover plant, showing tubercles on roots.

Causes of red clover failures. — The following are the main causes of red clover failures.

1. Seeding upon an improperly prepared seed bed is one of the first causes for red clover failures. Sowing red clover upon hard compact soils means almost sure failure. Red clover should be sown upon mellow, rather firm soils and about ½ to 1½ inches deep.

2. Red clover will not grow well upon a soil that lacks humus, hence a thin coating of manure will often produce results in getting a stand. Getting a stand is one of the prime essentials in successful red clover production.

3. In many instances red clover does not succeed because of the lack of lime. It will not grow well in an acid soil. Applications of $1\frac{1}{2}$ to 2 tons of ground limestone or about one-half that much burned lime per acre will correct this deficiency.

4. Red clover will not grow in a water-logged soil. It prefers deep, porous, open soils — clay soils first, black loams next, and sandy soils last.

5. Red clover sickness is a term which has caused much confusion, for to it were attributed all the failures of red clover production. There is no specific enemy causing clover sickness. Red clover failures are due to the following things, as summarized by Hunt in *Forage and Fiber Crops in America:* (1) Fungous diseases; (2) Insect enemies; (3) Lack or exhaustion of one or more essential elements, particularly potash; (4) Unfavorable physical properties of the soil and subsoil; (5) Acidity of soil; (6) Lack of tubercle forming and nitrogen gathering bacteria.

Culture of red clover. — Red clover is often sown in the spring in oat and wheat fields. From 8 to 10 pounds of seed are sown per acre. There are about 250,000 seeds per pound (60 pounds per bushel). Eight pounds evenly scattered upon an acre puts about 48 seeds to every square foot. Only good viable, plump seeds should be sown, and these should be free from all foreign seeds.

Red clover is a biennial and fits well into crop rotations. The tap roots of red clover penetrate the ground from 5 to 6 feet, but about 75 per cent of the roots are in the upper 8 to 10 inches. The roots of red clover are not so fibrous as those of the grasses. One thousand pounds or more of dry material of clover roots are left in an acre of soil. The proportion of roots to tops has been estimated to be as one is to two. Heavy crops have a larger quantity of roots.

Harvesting red clover. — Red clover should be cut when it will yield the maximum amount of dry matter and of protein, and leave the roots in the best condition for further growth. The stage of

maturity when all of these points are best maintained is when the plants are in full bloom. This is shown by the following data:[1]

YIELD AND NUTRIENTS IN AN ACRE OF RED CLOVER AT DIFFERENT STAGES OF MATURITY

	YIELD HAY, LB.	ASH, LB.	CRUDE PROTEIN, LB.	FIBER, LB.	NITROGEN FREE EXTRACT, LB.	FAT, LB.
Full bloom	3600	217	400	660	1052	197
Heads $\frac{3}{4}$ dead	3260	196	379	672	1024	156

It will be seen that more hay, ash, protein and fats are secured when red clover is in full bloom than later. This is an important thing to remember in harvesting red clover.

The leaves contain valuable nutrients and hence should be carefully preserved. This is well shown in the following data:[2]

PERCENTAGE COMPOSITION OF DIFFERENT PARTS OF RED CLOVER PLANT[3]

CONSTITUENTS	HEADS	STEMS	LEAVES	LEAF STALKS
Protein	18.25	8.06	24.63	11.16
Moisture	9.99	8.02	8.70	8.88
Ash	7.20	5.67	8.39	8.02
Ether extract (fat) .	2.86	1.25	5.00	2.18
Crude fiber	10.29	34.94	13.36	13.08
Nitrogen-free extract	51.41	42.06	39.92	56.68

It may be seen that the leaves are higher in protein than any other part of the red clover plant, hence the importance of carefully saving the leaves. It means that the plants must be put up before they become too dry. This principle is one that should be put into practice generally in haying. Red clover is usually harvested twice annually. The second crop is the seed crop.

[1] Illinois Station Bulletin No. 5. [2] Farmer's Bulletin No. 455.
[3] Analysis made by the Bureau of Chemistry.

Seed formation depends somewhat upon bumblebees to fertilize the flower. Red clover blooms will not be fully fertilized except by artificial means. Bumblebees are instrumental in propagating the red clover plant by carrying the pollen.

Uses of red clover. — Red clover is an excellent forage or hay crop. Hogs may be economically grown on red clover pasture. A bushel of corn fed to shoats weighing 60 to 75 pounds will put on 10 to 11 pounds of pork; but when fed with red clover pasture a bushel of corn will produce 15 to 18 pounds of pork.

For cattle, alfalfa hay alone excels red clover hay among the roughages. Tests on clover hay and timothy hay for feeding two-year-old steers were made at the Indiana Station[1] and the Missouri Station.[2]

Clover Hay vs. Timothy Hay for Fattening Steers

		Daily Gain, Lb.	Feed for 100 Lb. Gain	
			Corn, Lb.	Hay, Lb.
Lot I.	Clover hay, 9.8 pounds . . Shelled corn, 21.5 pounds . .	2.4	919	416
Lot II.	Timothy hay, 6.4 pounds . . Shelled corn, 18.8 pounds . .	1.8	1086	380

In the feeding trial at the Missouri Station corn was worth 8 cents per bushel more when fed with clover than with timothy hay. In each case the cattle ate more when fed clover hay, but made more economic gains.

For dairy cattle red clover hay is nitrogenous, and supplements a carbonaceous roughage, such as corn silage or corn. The digestible composition of corn silage, red clover, and a few other feeds follows:

[1] Bulletin No. 129. [2] Bulletin No. 76.

Percentage Digestible Composition of Some Feeds

	Dry Matter	Fat	Carbohydrates	Protein	Nutritive Ratio
Red Clover hay . .	87.1	1.8	39.3	7.6	1 : 5.7
Corn silage	26.3	0.7	15.0	1.1	1 : 15.1
Alfalfa hay	91.4	0.9	39.0	10.6	1 : 3.9
Milk	12.5	4.6	5.0	3.2	1 : 5.3

Red clover has an excellent composition and is an excellent feed.

II. *White Clover*

White clover is the most important pasture legume. It is perennial and grows best in moist, well-drained, black loam soils of limestone formation. White clover is found throughout the world; and the pastures of the southern, eastern, central and northern states abound with it. White clover propagates itself by seeds and by its trailing stems. The seeds are hard and pass through animals unharmed. The trailing stems grow roots at each node. These two facts added to the fact that white clover is a long-lived perennial insure the plant excellent means for perpetuation. When white clover is seeded in mixtures, from 2 to 4 pounds of clover seed are used per acre. White clover seed is like alsike clover seed but is smaller, and has a pale yellow color.

White clover should be found in every pasture for three reasons: (1) It is a legume and therefore balances a blue-grass feed; (2) It is a legume, and therefore stores nitrogen in the soil, thus aiding blue-grass in its growth; (3) It grows in midsummer when blue-grass does not do so well.

III. *Sweet Clover*

Sweet clover, at one time considered a noxious weed, is rapidly coming into common use for the following advantages that it possesses: (1) It will grow on almost any type of soil. Farmer's Bulletin No. 797 states that it has been grown successfully on all

the principal soil types of the United States where the soils were inoculated and were not acid. It can be sown in poor soils on farms, along roads and railroad cuts which are too poor to produce any other crop. (2) Sweet clover produces a lot of excellent feed — more than can be produced by some of the other crops. At the Utah Station sweet clover yielded 7700 pounds per acre when alfalfa, timothy and alsike clover produced 2860, 2340 and 3560 pounds respectively. (3) Sweet clover is well liked by sheep, swine, horses and cattle after they become accustomed to it. It is an excellent feed. (4) Sweet clover is a good

Courtesy Farmer's Bulletin.

FIG. 53. — White sweet clover at Arlington, Va., showing the effect of inoculation upon their growth. The plants at the left represent the average growth on the inoculated plats; those at the right the average growth on the plats not inoculated. The plats had been previously limed and were seeded on the same date.

preparatory crop for alfalfa, for it opens up the soil, and if the sweet clover was inoculated it provides in abundance the bacteria

FIG. 54. — Wonderful growth of nodules, containing the nitrogen-gathering bacteria, on upper portion of sweet clover root. Found growing in the beach sand of Lake Michigan in North Michigan.

essential for alfalfa production. Sweet clover may be best inoculated by the soil transfer method. Scatter over each acre to be sown to sweet clover 200 to 400 pounds of soil from a field where sweet clover is growing. Soil inoculation is best done on a cloudy day, for sunshine quite rapidly destroys the bacteria. The soil used for inoculation should be harrowed into the ground immediately. (5) As an improver of the soil, sweet clover has hardly an equal. The attached cut shows deep penetrating root characteristics of the sweet clover plant. And also note the abundance of nodules formed by free nitrogen-gathering bacteria. (6) Sweet clover is a biennial and needs to be resown only every two years. This is an advantage over many other crops that have to be sown or planted yearly.

Culture of sweet clover. — Sweet clover does best on a limestone soil,—well compacted when sown. Liming the soil for sweet clover never harms its growth and usually improves it. It likes lime so well that it will grow in pure, crushed limestone. Proper inoculation is absolutely essential for the best production of sweet clover.

It is generally sown in the spring and from 20 to 25 pounds of seeds are sown per acre. In many cases it is sown like red clover — in early spring when the soil is in the honeycomb condition.

There are two well-known varieties of sweet clover, the white and the yellow sweet clover. White sweet clover bears white flowers and the yellow variety yellow flowers. The two varieties have other slightly different characteristics. The first variety is recommended as being the best by practically all the data available. It is quite likely that as sweet clover is being grown more, other varieties will be developed.

For a pasture crop, sweet clover should be grazed rather closely, and when the plants get taller than 8 to 12 inches they should be mowed.

Although not a good hay crop, it is often used as such. The first year it will furnish one cutting, which should be mowed rather high in order not to kill the plant. Two or three cuttings may be

secured the second year. It should be cut before the plants begin to bloom; for if it is cut much later, the stem becomes hard and more leaves are lost.

Courtesy Ohio Station.

FIG. 55. — Hogs are particularly fond of sweet clover. It should be clipped occasionally to keep it at a height of about eight to ten inches.

Value of sweet clover as a feed. — At the Wyoming Station[1] the following results were secured with various feeds with lambs.

SWEET CLOVER FOR LAMBS

LOT	NUMBER IN LOT	RATION	COST OF FEED PER 100 LB. GAIN
1	40	Alfalfa hay and corn	$4.26
2	40	Native hay, oats and oil meal . . .	6.63
3	40	Alfalfa hay and corn	4.01
4	40	Sweet clover, hay, corn, oil meal . .	4.93

The bulletin states that lot 4 in 14 weeks made 30.7 lb. gain, and that lot 3, fed alfalfa, made 34.4 lb. gain in the same time. The lambs liked sweet clover hay and showed a steady appetite for it.

[1] Bulletin No. 79.

The following unpublished data from the Iowa State College give the value of sweet clover in comparison to red clover for hog pasture.

GAIN OF HOGS ON DIFFERENT PASTURES AND AMOUNT OF GRAIN FED

First Period, June 22–September 14

KIND OF PASTURE	TOTAL GAIN (Pounds)	SHELLED CORN CONSUMED (Pounds)	GRAIN REQUIRED FOR 100 LB. GAIN (Pounds)
Sweet Clover . . .	811	2607	321.5
Red Clover . . .	872	2266	259.9

Second Period, September 14–November 10

KIND OF PASTURE	TOTAL GAIN	ADDITIONAL FOOD CONSUMED		AMOUNT OF REËNFORCEMENT TO 100 LB. GAIN	
	(Pounds)	Shelled Corn (Pounds)	Meat Meal (Pounds)	Shelled Corn (Pounds)	Meat Meal (Pounds)
Sweet Clover	1783	5529	640	310	36
Red Clover	1430	4900	567	342	40

The size of the plots on which these gains were made was 0.8 of an acre. It will thus be seen that the red clover gave slightly larger and more economical gain in the first part of the pasture season, but that it fell considerably behind in the total gain and in economy of production as the grazing season advanced.

The fact that sweet clover thrives on so many soils on which other valuable plants will not grow, that it is a superior soil builder, and such an excellent feed and yielder, insures it a more extensive use in the future.

IV. *Alsike Clover*

Alsike clover originated in Sweden, near a place named Alsike, from which it gets its name. It is a perennial which lives from

3 to 5 years. It will grow in acid soils and in wet places where red clover will not grow. Alsike makes an excellent hay because it has a smaller stem and is more easily cured than red clover. When sown in a mixture with other grasses, from 4 to 6 pounds of seeds are usually sown per acre. It has a white, pinkish flower, and purple or yellowish green, heart-shaped seeds a little larger than white clover seeds.

V. *Crimson Clover*

Crimson clover is an annual legume. It is not grown where there are hard freezing winters. In the United States it is grown most extensively along the Atlantic coast. Crimson clover stools readily. The seeds are larger than those of the rest of the clovers, and have a shiny crimson color.

Summary. — The clovers are among our most important plants because they occupy a large acreage, and because they yield well, protect the soil, and make excellent feeds. Soils should be well prepared before clover seeds are sown. Inoculating the soil usually helps in clover production and never harms. The clovers make excellent feed, for they are rich in protein and lime. The most important legume pasture plant is white clover, and the most important legume hay plant is red clover. Sweet clover is bound to increase in popularity, and alsike and crimson clover are excellent plants because of their adaptability. The growth of these legumes may be well encouraged.

QUESTIONS

1. Describe the botanical characteristics of red clover and sweet clover.
2. What kinds of soils does each of the clovers prefer? Why?
3. Compare the composition of red clover hay, alfalfa, and white clover pasture.
4. What are the especial advantages of alsike clover?
5. Put in the form of a graph the ten leading states in the production of red clover.

PROBLEMS

1. Compare the seeds of all the clovers and alfalfa as to shape, color and size.
2. Report upon how to grow and harvest red clover for seed.

REFERENCES

Piper, Forage Plants and Their Culture.
Hunt, Forage and Fiber Crops in America.
Wilson and Warburton, Field Crops.
Henry and Morrison, Feeds and Feeding.

CHAPTER VII

ALFALFA

History of alfalfa. — Alfalfa originated in southwestern Asia. It is among the oldest of forage plants, and was used centuries before the Christian era. Alfalfa was successively carried from Media through the Persian War, 480 B.C., to Greece; to Italy, the first century A.D.; to Spain through the Saracen Invasion, about the eighth century; to Mexico and South America by the early explorers, in the 16th century; to California from Chile in 1854 and from thence to all parts of the United States. Attempts prior to 1854 to grow alfalfa in the United States were failures. Since that time it has come to be the third most important hay crop in the United States. It is an important crop also along the Mediterranean Sea, and in Argentina, Chile, Peru and Australia, Central Asia and South Africa. Soil and climatic conditions are the factors limiting its distribution.

Importance of alfalfa in the United States. — Alfalfa occupied 7,400,000 acres in 1909; clover alone occupied 14,600,000 acres, and clover and timothy 19,500,000 acres in the same year.

THE LEADING ALFALFA STATES

	Acreage	Per cent (0% 2% 4% 6% 8% 10% 12%)
United States	7,400,000	
Kansas	957,000	12.8%
Nebraska	685,000	9.5%
Colorado	508,000	6.7%
California	484,000	6.5%
Idaho	309,000	4.0%
Nevada	284,000	3.7%
Montana	225,000	3.0%
Wyoming	170,000	2.3%
Oregon	120,000	1.5%
New Mexico	102,000	1.3%
Rest of the United States		50.7%

The above ten states have 49.3 per cent of the alfalfa acreage, and it is quite probable that they produce more than 50 per cent of the total tonnage of alfalfa produced in the United States.

The appended map indicates the exact alfalfa acreage in the various states.

Advantages of alfalfa production. — 1. Alfalfa is the equal, or the superior, of any other plant as a soil builder. Professor D. H. Hughes, of the Iowa Agriculture College says: "As a soil builder

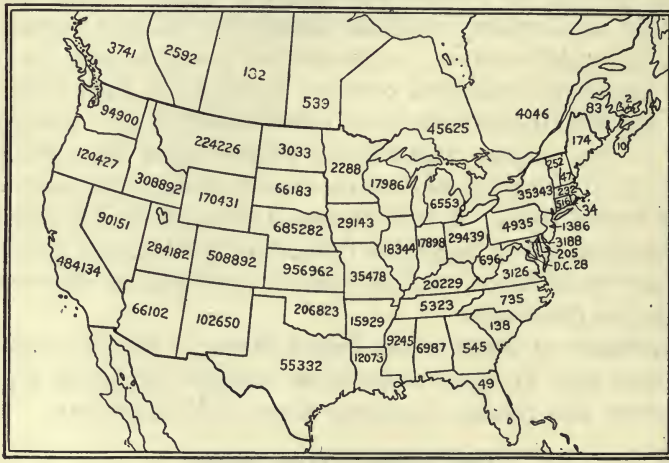


FIG. 56. — The above map shows the alfalfa acreage of the United States. Figures denote acres.

it is estimated that an acre of alfalfa adds annually over twice as much nitrogen to the land as the average acre of red clover." Alfalfa is a legume, and the legumes have the capacity through the bacteria that cause nodules on the roots to fix the nitrogen from air in the soil. However, the erroneous impression that alfalfa builds up the soil in all of the plant food elements should be corrected, for alfalfa takes other important plant food elements out of the soil just as other plants do, as shown by the following table:[1]

[1] Henry and Morrison.

Amount of Phosphorus, Potassium, and Lime Removed per Ton (Air Dry)

	Phosphorus	Potassium	Lime
Alfalfa	10.8 pounds	44.6 pounds	39.0 pounds
Wheat	59.0 pounds	33.0 pounds	1.8 pounds
Timothy	6.2 pounds	27.2 pounds	5.0 pounds

On account of the deep and extensive root system alfalfa leaves much vegetable matter in the soil. This additional organic matter improves the physical and chemical condition of the soil.

The deep, penetrating roots secure most of their plant foods from depths where the grasses do not penetrate. This rests the surface soil. Much plant food thus gathered from lower strata is left near the surface of the soil.

2. The second large advantage of alfalfa production is that it produces more hay per acre annually than does timothy or clover. The average yield of alfalfa is 2.14 tons per acre, and for timothy and clover it is 1.22 tons per acre.

The following table is based upon the average returns from the average crops throughout the United States.

Returns per Acre of Alfalfa and Other Farm Crops

	Yield per Acre, Lb.	Dry Matter, Lb.	Digestible Crude Protein, Lb.	Digestible Carbohydrates and Fats, Lb.	Net Energy Therms
Alfalfa hay	5040	4632	529	2143	1734
Clover hay	2580	2185	183	1080	896
Timothy hay	2440	2118	68	1106	819
Corn (ears and stover)	3440	2604	140	1824	1762

A thorough comparison of the figures of the above table will reveal many arguments for alfalfa — for it is a splendid producer of the necessary food ingredients.

Alfalfa is, moreover, a more nutritious feed than timothy or clover, as the following table shows:

PERCENTAGE DIGESTIBLE COMPOSITION OF ALFALFA, CLOVER AND TIMOTHY

	TOTAL DRY MATTER	PROTEIN	CARBO-HYDRATES	FAT	TOTAL	NUTRITIVE RATIO
Alfalfa . . .	91.4	10.6	39.0	0.9	51 6	1 : 3.9
Clover . . .	87.1	7.6	39.3	1.8	50.9	1 : 5.7
Timothy . .	88.4	3.0	42.8	1.2	48.5	1 : 15.2

It will be noted that in each 100 lb. of alfalfa we find more digestible nutrients than we find in clover or timothy hay and also that alfalfa is much richer in protein.

3. Alfalfa is readily eaten as a hay by practically all farm animals, and for meat production, for growing animals, and for milk production it has no equal among the hay plants.

4. Alfalfa is drought resistant. It will grow in the arid regions where few other good hay plants will grow. It can therefore be produced upon otherwise waste lands.

Uses of alfalfa. — Alfalfa is grown to produce alfalfa hay; and as has already been shown, alfalfa excels the other hay crops in producing nutrients for the growing animal. Alfalfa is extensively grown on account of the immense amount of protein it produces. At the New York Station the following amounts of protein were produced by different crops per acre.

Alfalfa	815 pounds protein
Clover	491 pounds protein
Oats and Peas	350 pounds protein
Corn, entire crop	300 pounds protein
Mangels	232 pounds protein
Timothy	228 pounds protein
Sugar Beets	213 pounds protein

Alfalfa, according to these records, produced almost twice as much protein per acre as did red clover, and four times as much as

timothy or sugar beets. The high *lime* and *protein* content make alfalfa an excellent feed.

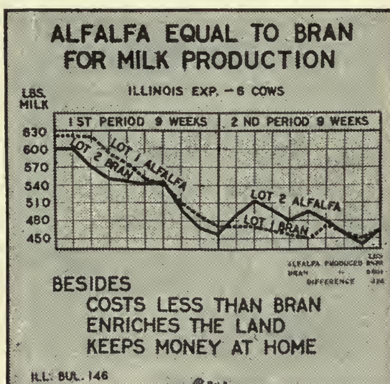
Alfalfa hay is very similar in composition to wheat bran. It is claimed by dairymen that eleven pounds of alfalfa are equal to ten pounds of wheat bran for milk production. The percentage of digestible nutrients in 100 pounds follows:

PERCENTAGE DIGESTIBLE NUTRIENTS

	Total Dry Matter	Crude Protein	Carbo-hydrates	Fat	Total	Nutritive Ratio
Corn for comparison	89.5	7.5	67.8	4.6	85.7	1 : 10.4
Hay alfalfa . . .	91.4	10.6	39.0	0.9	51.6	1 : 3.9
Bran	89.9	12.5	41.6	3.0	60.9	1 : 3.9

It will be noted that alfalfa and bran have about the same digestible nutrients, and that the nutritive ratio is the same.

Alfalfa proved superior to bran in an experiment conducted by the Illinois Station. Bulletin No. 146 gives us the following data. There were six cows in the experiment — three in each lot. All of these cows freshened in December. The experiment lasted 18 weeks — divided into two equal periods, — all feed given was the same in amount throughout the experiment. Everything was the same except one group of cows was fed bran the first nine weeks and alfalfa the other nine weeks. The other group was fed alfalfa the first nine weeks and bran the last nine weeks. The results of the experiment are shown in the above figure.



Courtesy International Harvester Co.

FIG. 57. — Alfalfa equal to bran for milk production.

It may be noticed from the figure that the milk produced by lot 2, fed on bran when changed to alfalfa, immediately rose above lot 1, and remained above. The total milk produced in favor of alfalfa, for the 18 weeks, was 375 pounds. Alfalfa is practically equal to bran as a feed for milk production.

Factors aiding increased yields of alfalfa. — 1. *The soil.* The kind of soil upon which alfalfa is grown is the first essential to successful alfalfa production. Rich bottom loams comprised of soils made of clays, silt, and sand are best suited to alfalfa growing. The soil must be fertile, having plenty of humus and some lime, — mellow and friable, and in first-class mechanical condition.

Alfalfa is sensitive to an acid or sour soil and will not grow in such a soil until the acidity is corrected by the addition of lime. From two to four tons of ground limestone may be used where the soil is quite acid. The subsoil should be loose, *pervious*, and in a condition to admit the deep penetrating roots of the alfalfa plant. The roots of alfalfa are on an average three to six feet long and a soil that contains surface hardpan will therefore not admit alfalfa roots. They will not penetrate a hard soil or subsoil.

Alfalfa will not grow in a wet soil. The water table should be not closer than six or seven feet from the surface. Deep, well-drained soils are required to secure the best results.

2. *A good seed bed.* Seed bed preparation is an important factor in alfalfa production. The seed bed should be mellow but firm, and free from weed seeds. Plowing and preparing the soil 6 or 8 weeks in advance of seeding, and cultivating it about a week after each rain, prepares the soil by giving the bacteria in the soil longer chance to make plant foods available, and by destroying weed seeds. If the seed bed does not contain the bacteria which are essential to its growth, then the soil should be inoculated. The soil may be inoculated by scattering from 300 to 500 pounds to the acre of soil from a field where alfalfa or sweet clover has been growing.

L. E. Call, agronomist of the Kansas Station, says relative to the inoculation of alfalfa: "The soil method of inoculation is the

surest, safest, and generally the best method of inoculation. An old field of alfalfa or sweet clover that is well set with nodules should be found. The surface inch should be scooped off and the next four or five inches of soil taken for inoculating purposes. The soil should be broadcasted without drying as soon as possible over the field to be inoculated. The work should be done on a cloudy day if possible, and the soil harrowed in immediately after it is scattered."

Courtesy Ill. Station.

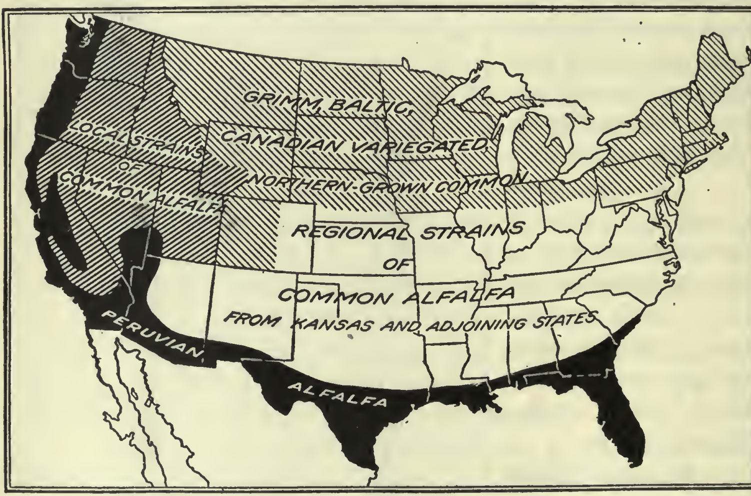
Fig. 58. — Alfalfa plants showing an uninoculated plant on the left and an inoculated plant with root tubercles and increased growth on the right.

3. *The right kind of seed.* The kind of seed and its source is also an important factor in alfalfa production. Although about 90 per cent of the alfalfa grown in the United States is of the American varieties, farmers are sifting out the varieties of alfalfa and are growing those that are most prolific. There are about a dozen fairly well-defined varieties of alfalfa, among which the following are recommended by the United States Department of Agriculture. "The leading varieties of alfalfa are the Grimm, the Baltic, the Canadian Variegated, and Sand Lucern."

Farmers should write to their own state experiment station for information as to what variety of alfalfa is best adapted to their state and immediate locality.

If all other things are equal, home grown seed should be sown, for it usually does best. However, if superior varieties can be secured from elsewhere, it may be profitable to use them.

4. *When and how to sow alfalfa.* Sowing alfalfa properly is an important factor in its production. The time of seeding varies



Courtesy U. S. Department of Agriculture.

FIG. 59. — Outline map of the United States, showing the varieties or strains of alfalfa that are recommended for various sections, based upon climatic conditions.

with the soil conditions and season, but in many places June, July, or August is a good time for seeding.

Sometimes early spring sowing is preferred. But fall sowing has the advantage in that the alfalfa gets a start of the weeds.

Twenty to thirty pounds of seed are sown per acre. There are about 220,000 seeds in a pound and 60 pounds to the bushel. Twenty pounds of alfalfa seed evenly distributed over an acre (43,560 sq. feet) scatters about 100 seeds per square foot.

The depth of seeding varies according to the soil and season conditions, but ordinarily alfalfa seed is sown from one-half to one and a half inches deep.

5. *Cultivating alfalfa.* Cultivation of alfalfa is an important factor in its production. The life period of alfalfa ranges from three to six years ordinarily. However under good care in some conditions it has grown for twenty-five or more years. Some varieties are longer-lived than others. Weeds are alfalfa's worst enemy. The disk harrow has been recommended as the best tool to eliminate weeds from alfalfa, but the old theory that "you can't scratch the back of alfalfa too hard," is passing, because it is possible to treat the plants too roughly. It is for this reason that the spring toothed harrow and the ordinary spike toothed harrow are now recommended for cultivating alfalfa. The grasses and weeds must be kept out of alfalfa if it is to have a long life. Proper cultivation prevents the necessity of plowing up alfalfa fields, and therefore cheapens its production.

6. *Manures for alfalfa.* Barnyard manures may increase the alfalfa crop. The effect of barnyard manure upon alfalfa production is shown in the following data from the Kansas Station:[1]

EFFECT OF BARNYARD MANURE — ALFALFA YIELD IN POUNDS

	1911	1912	1913	1914	1915	AVERAGE YIELD
Manure $2\frac{1}{2}$ tons yearly	3659	1620	3041	4342	8537	4239
No treatment . . .	2463	820	1901	2330	4409	2384
Excess due to manure						1855

In Iowa Experiment Station Bulletin No. 137, we read: "Eight to twelve tons per acre of good manure should be applied before plowing for alfalfa, for the use of manure is by far the most important factor in securing successful results on Iowa soils. It is a notable fact that of twenty-three correspondents who make

[1] Kansas Station Bulletin No. 238.

special mention of the fact that they have manured their fields before plowing but one failed. While good stands and yields of alfalfa have been secured on fertile soils without manure, yet yields are in almost every case largely increased by its use. On soils of only medium fertility manure is essential to the greatest success; on soils below the average successful stands are practically never secured without its liberal use."

Ex-president H. J. Waters of the Kansas Agricultural College, in his very excellent new work, *Essentials of Agriculture*, says: "On most soils the use of manure is the most important factor in securing satisfactory results. While good stands and yields of alfalfa have been secured on fertile soils without manure, the use of manure in almost every case lessened the risk of failure to get a stand and has greatly increased the yield."

Manures also add organic matter which provides food for bacteria in the soil. This is an additional item of importance in producing alfalfa.

7. *Harvesting and curing alfalfa.* Proper harvesting and curing are important considerations in the production of alfalfa. Alfalfa should be cut when the new shoots from the crown are about an inch long. It should be cut at this time even if the crop is small. Much more is lost in the subsequent crops than will be gained in the first crop by waiting, for the new stems or shoots will be cut off and the next crop will be seriously handicapped. In the fall it is advisable to allow considerable growth, as a winter covering from the cold.

Some farmers cut the alfalfa when from $\frac{1}{10}$ to $\frac{1}{3}$ of the plants are in bloom. The protein content in alfalfa is higher at this period than later. The Kansas Station gives us the following data:

Percentage Protein in Alfalfa at Different Stages of Growth

When $\frac{1}{10}$ in bloom	18.5 per cent protein
When $\frac{1}{2}$ in bloom	17.2 per cent protein
When in full bloom	14.4 per cent protein

Since the protein is the most valuable ingredient in alfalfa, we may harvest it, according to the rule, when about $\frac{1}{10}$ of the plants are in bloom.

The leaves contain about 75 per cent of the protein, and the stems about 25 per cent. For this reason after the alfalfa is cut and has dried to some extent it should be put into cocks, before it gets so dry that the leaves will be lost. After it has dried in the cocks for about a day it should be stacked or stored in a barn. The importance of saving the leaves is shown by the following table:

THE PERCENTAGE COMPOSITION OF ALFALFA STEMS AND LEAVES, WHEN $\frac{1}{10}$ PLANTS ARE IN BLOOM

	RELATIVE PER CENT OF EACH	ASH	CRUDE PROTEIN	CRUDE FIBER	NITROGEN FREE EXTRACT	ETHER EXTRACT
Leaves . .	56.40	10.52	24.16	14.06	37.40	4.06
Stem . .	43.61	7.97	10.63	35.12	32.97	1.33

It may be seen from this table that the leaves contained 24 per cent protein, and the stems only 11 per cent. This shows the importance of saving the leaves in curing and harvesting.

Summary. — Alfalfa is among the oldest plants, and its spread though recent has been rapid. Alfalfa is growing in importance. Kansas is the leading state in alfalfa production. There are several advantages in growing alfalfa, and where it thrives few crops excel it in production of feed. Acid soils, wet soils, and soils lacking the proper bacteria will not grow alfalfa. Alfalfa is an excellent feed for almost all farm animals. Eleven pounds of alfalfa are more than equal to ten pounds of wheat bran as a dairy feed. The factors influencing alfalfa production are: (1) kind of soil; (2) seed bed preparation; (3) kind of seed; (4) method and time of sowing; (5) cultivation; (6) barnyard manures; (7) use of lime and inoculation of the soil. Wherever alfalfa will grow, — and it is believed that it will grow where corn grows,— its growth should be encouraged.

QUESTIONS

1. What is the importance of the alfalfa crop and what are the leading alfalfa states?
2. What are the advantages of alfalfa?

3. What are the principal causes of alfalfa failures?

4. Discuss the factors which help to increase acreage yields of alfalfa.

5. How should alfalfa be harvested in order to secure the most and the best hay?

6. Compare the lime and phosphorus content of alfalfa and wheat.

PROBLEMS

1. Report upon the culture of alfalfa in your locality, and make such additional suggestions as seem practical on the subject.

2. Give in detail the experimental data from 4 or 5 actual feeding trials with alfalfa in contrast or comparison with other feeds.

REFERENCES

Piper, Forage Plants and Their Culture.
Henry and Morrison, Feeds and Feeding.
Coburn, The Book of Alfalfa.
Hunt, Forage and Fiber Crops.

CHAPTER VIII

SOY BEANS

History. — The soy bean originated and was developed in southeastern Asia, especially in the countries of China and Japan. In these oriental countries over 200 varieties have been developed, where they are used for human food. Soy beans were grown in Austria for a number of years experimentally, and in 1875 a report was published urging a more extensive use of this important annual leguminous plant. Although soy beans were introduced into the United States about a century ago, they were not very extensively grown. And even to-day soy beans are not as extensively grown as their value warrants.

Importance of soy beans. — Soy beans do not occupy a large acreage at the present time, but the crop is increasing in popularity. Soy beans grow farther north than do cowpeas, and they promise to become one of the leading legume crops of the Middle and Northern States. As a pasture, hay, and seed crop, and as a soil renovator soy beans have few superiors.

Botanical features of the soy bean. — Soy beans grow erect and possess many seed pods, each one usually bearing three seeds. The stems, foliage, and seed pods are very hairy. The roots of the soy bean penetrate deeply into the soil and bear many nodules containing bacteria which take free nitrogen from the air and put it into the soil.

Why raise soy beans? — 1. Because of their erect habit of growing, they may be planted with corn. Cowpeas vine too much, and thereby hinder cultivation. Soy beans do not interfere with cultivation.

2. Soy beans yield a larger quantity of seed than cowpeas. Soy beans will yield from twelve to eighteen bushels; cowpeas, from eight to twelve.

3. Different soy bean varieties mature in 75 to 165 days. This adapts them to either southern or northern conditions.

4. Soy beans store as much nitrogen in the soil as do cowpeas, and the leaves and seeds contain more protein than do those parts of the cowpea plant.

5. Soy beans do not shatter as easily as cowpeas. This adapts them to various methods of handling, such as haying, threshing, or hogging down.

Soy bean varieties. — Soy bean varieties vary in size of plant, amount of seed produced, time required for maturity, color of seed, etc.

THE CHARACTERISTICS OF A FEW VARIETIES OF SOY BEANS

Variety	Color of Seed	Days for Maturity	Size of Plant	Characters
Mammoth Yellow	Light yellow	150–155	35–38 in.	Erect, foliage abundant
Ito San	Straw	110–115	25–30 in.	Erect, leaves fine, average amount of seed
Hollybrook	Straw	125–130	36–38 in.	Good for forage and seed production
Mikado	Green	130–135	32–35 in.	Heavy seed producer and medium forage
Brown Dwarf	Brown	90–100	15–18 in.	Scant foliage and little seed
Black Beauty	Jet black	125–130	33–36 in.	Foliage and seed medium

The varieties recommended for your state may be secured by writing the Chief Agronomist.

Culture of soy beans. — The seed bed for soy beans is prepared like the seed bed for corn. The soil is plowed five to eight inches deep, and then well compacted, with the upper two or three inches worked into a soft, mellow mulch.

The rate of seeding varies from 20 to 30 pounds to the acre where the crop is to be cultivated. Where broadcasted from 60 to 90 pounds are usually sown, depending upon the size of the seed. The planted rows are from 36 to 38 inches apart, and are cultivated like corn. Shallow cultivation, where the seed bed was properly prepared, has proved to yield best results. The average depth of planting ranges from one to three inches.

FIG. 60. — The roots and top of the soy bean plant. Note the nodules.

Inoculation of the soil never does harm and usually does good, if the soil is not already inoculated. Methods of inoculation similar to those described in connection with alfalfa raising may be employed. The soil should, of course, be taken from a field where soy beans have been growing.

The *glue method* of inoculating suggested by the Illinois Station is very satisfactory. A solution is prepared by dissolving six ounces of glue in a gallon of water. Moisten the soy beans with the solution and sift over them well-pulverized, inoculated soil.

Apply sufficient soil to give a thin coating for each seed. Stir all the seeds until they are dry, and plant within a few days.[1]

If soy beans are to be harvested for hay, they should be cut when the pods are well formed but not mature. If the leaves are to be saved, — and they should be saved, for they contain an abundance of nutritious feed, — most of the curing must be done in the cock. Late cutting gives the stems a chance to become hard and woody, and therefore should not be practiced in harvesting hay crops where the stems of the plants are large and fibrous. If soy beans are put into the silo, they may be harvested a little later. If harvested for seed, they should be well matured. From one to two tons of hay may be expected, and from 12 to 20 bushels of seed per acre for an average year.

The selection of the adaptable and prolific variety of soy beans for the particular conditions of the locality is an important factor in securing maximum yields. At the Illinois Station, the following results were secured:[2]

Seed			Hay	
Variety	Years	Average Bushels	Years	Average Tons
Medium yellow . .	1904–12	15.3	1904–16	1.61
Omega	1904–12	5.7	1904–05	0 585

In the above, extreme cases have been taken, for the variety Omega was a very poor producer in both seed and hay.

Uses of soy beans. — Soy bean hay, silage and the grain make an excellent nitrogenous feed for live stock. The value of soy bean hay in comparison with alfalfa hay is shown in the following data from the Tennessee Station.[3] The data are those obtained from three thirty-day periods when the rations were fed alternately.

[1] Illinois Station Bulletin No. 198. [2] Bulletin No. 198.
[3] Bulletin No. 80.

Soy Bean Hay vs. Alfalfa Hay

(With two lots of 4 cows each)

Ration I

		Average Daily Yield	
		Milk, lb.	Fat, lb.
Soy bean hay	7.1 lb.	17.2	0.98
Ground soy beans	3.7 lb.		
Corn and cob meal	3.7 lb.		
Silage	25.0 lb.		

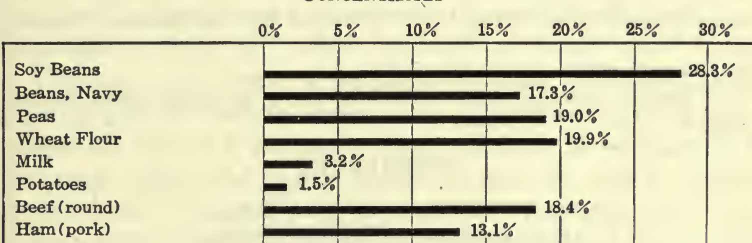
Ration II

		Average Daily Yield	
		Milk, lb.	Fat, lb.
Alfalfa hay	12.3 lb.	15.1	0.80
Silage	24.6 lb.		
Corn and cob meal	3.7 lb.		

This experiment indicates that soy bean hay is superior to alfalfa hay for milk production, yielding 2.1 lb. more milk per day, and slightly more fat.

The soy bean seed is a valuable human food. Soy bean seeds are highly nitrogenous.

Pounds of Digestible Protein in 100 Pounds of Soy Beans and Other Concentrates



Bulletin No. 312, Ohio Station, states: "If soy beans were to come into general use as a food, two important results would follow: namely, the needed market for soy beans would become

established and the growing of them would become more general, which seems to be desirable from the standpoint of the farmer, and, moreover, a large amount of highly nutritious food would be more available at very low cost, thus affording relief from the constantly increasing cost of living."

Summary. — Soy beans are increasing in popularity. The varieties grown most are the Mammoth Yellow, Ito San, Mikado, Medium Early, Green, Early Black, and Mongul. Soy beans may be used as a hay, silage, forage, or seed crop. They are used as feed, although they are excellent for human use. Soy bean hay and the seeds are slightly nitrogenous. The growing of soy beans is increasing. The soy bean is an excellent feed, and as a soil renovator and builder it has few, if any, superiors.

QUESTIONS

1. Discuss the history of soy beans as given in the encyclopedia.
2. Describe the botanical characteristics of soy beans.
3. What are the advantages of soy beans?
4. What is meant by inoculating for soy beans? Describe two methods of soil inoculation for soy beans.
5. Compare the composition of soy beans with that of corn silage and wheat.

PROBLEMS

1. Compare the botanical features of soy beans with those of cowpeas, garden beans and peas, the clovers and alfalfa. What plants are included in the legume family?
2. Bring to class and describe the varieties of soy beans grown in your locality.

REFERENCES

Piper, Forage Plants and Their Culture.
Henry and Morrison, Feeds and Feeding.
Bailey's Encyclopedia, Vol. II.

CHAPTER IX

COWPEAS

History. — The cowpea is native to southeastern Asia. China and India deserve the credit for the origin and improvement of this important legume. Cowpeas were introduced into the West Indies in the early part of the 18th century and were well known in the Carolinas in 1775. Virginia grew them by 1795, and they were soon in general use, especially in the Southern States.

The cowpea is more like a bean than a pea, having large, broad leaves and long, slender pods. Its great value as a forage crop and its ability as a soil improver have given it an important and secure foothold on many farms in the southern and central sections of the United States.

Culture and importance of cowpeas. — The cowpea is extensively grown in the South. In the section where cotton is grown it is the most important of the legume crops. Although data regarding cowpeas are meager, the number of acres harvested in the South in 1909 for seed purposes was 209,604 acres. Cowpeas are used as a forage and hay crop, and to some extent as a human food.

Cowpeas are planted or sown about two weeks after corn planting time and up to within 90 days of the first killing frost. A well-prepared seed bed is essential to best results in the production of the crop. When the crop is wanted for hay the seed is usually broadcasted. If a seed crop is wanted, it is usually sown with a grain drill far enough apart so that cultivation may be practiced. The seeds should be covered from $1\frac{1}{2}$ to 2 inches deep. The rate of seeding for a hay crop is from 4 to 8 pecks, and for a seed crop from 3 to 4 pecks. The harvesting of cowpeas will be mentioned in a later paragraph.

Advantages of growing cowpeas. — The cowpea will grow in almost any kind of mellow, well-drained soil, and as a soil builder it has few equals. It is a typical legume, gathering nitrogen from the air and fixing the nitrogen in the soil through the action of bacteria in its roots.

Cowpeas produce either a good hay or seed crop. From $1\frac{1}{2}$ to 2 tons of good hay or from 8 to 12 bushels of seed may be expected under usual conditions and seasons. (The leaf and pod characteristics are shown in the picture, page 148.)

Cowpeas are very rich, in comparison to other plants, in protein and carbohydrates. The following table gives a fair comparison.

Percentage Digestible Composition of Cowpeas and a Few Other Crops

	Total Dry Matter	Protein	Carbohydrates	Fat	Nutritive Ratio
Cowpeas (grain) .	85.4	16.8	55.0	1.1	1 : 2.9
Corn (grain) . .	89.4	7.8	66.8	4.3	1 : 10.4
Cowpea hay . .	89.5	9.2	39.3	1.3	1 : 2.7
Alfalfa hay . .	91.9	10.5	40.5	0.9	1 : 3.9

Cowpea hay and cowpeas have a relatively high percentage of protein, and since the nutritive ratio of these feeds is narrow, they are highly desirable as supplements to carbohydrate feeds.

Factors aiding in increasing the yields of cowpeas. — (1) All the ordinary factors, such as season, culture and harvesting, are important in increasing the yields of cowpeas; (2) Using the varieties adapted to the purpose for which they are grown, and to the locality and soil conditions, is essential for the best results.

Cowpea varieties have different characteristics as to time of maturity, length of stem, leafiness and amount of seed. The following table gives a brief summary of some of these characteristics for a few leading varieties:

Variety	Color of Seeds	Days Required for Maturity	Regarding Vining	Purposes
New Era .	Reddish brown	110–115	Little	Better for seed
Clay . . .	Tan colored	120–125	Light in forage	Medium seed and vegetation
Early Blackeye . .	White with black eye	115–120		Seed and some forage
Taylor . .	Tan mottled with gray	110–115	Light in forage	Seed and some forage
Warren . .	Dark tan in color	110–115	Vines more	Good for forage
Whippoorwill . .	Dark brown and light colored spots and streaks	115–120	Great viner	Better for vegetation, hay, etc.
Red Ripper	Seeds are reddish brick colored	110–115	Vines more	Lots of forage

The varieties of cowpeas, at the Indiana Station, have varied in seed and hay production as shown in the following table:

Average Yields of Cowpeas — 1906–1912 (Inclusive) per Acre

Variety	Northern Part of State		Southern Part of State	
	Bushels Seed	Pounds Hay	Bushels Seed	Pounds Hay
Early Blackeye . .	12.2	3031	11.2	2515
New Era	11.3	3154	9.9	2854
Whippoorwill . . .	13.0	3459	10.8	2762
Michigan Favorite .	13.5	3362		
Black		4099	8.1	2967
Iron			7.2	3938
Clay			5.1	3865

From this table it may be seen that the Michigan Favorite yielded 2.2 bushels more than the New Era. Again, the Black yielded 1068 pounds more hay per acre than did the Early Blackeye. The variety sown should be carefully considered, from the standpoint of purpose and local soil condition. The varieties described

in the above table possess sufficient variations to meet almost all conditions, and are the leading varieties of the country.

The time of harvesting is a factor in getting the most out of cowpeas. The time of harvesting depends upon the purpose for which they are to be used. The best time to cut for hay is when

FIG. 61. — The parts of a cowpea. Notice the nodules in which bacteria live that gather free nitrogen from the air and store it in the soil.

the seeds are well formed, some of the pods are ripe and the lower leaves have begun to turn yellow. Harvesting at this stage of maturity gives the greatest amount of nutrients in the most digestible form. The following table gives the composition of cowpea hay harvested at different stages of maturity.

Composition of Cowpea Hay Harvested at Different Stages of Maturity (Air Dry)

Stage of Development	Protein Per Cent	Fat Per Cent	Fiber Per Cent	Nitrogen Free Extract Per Cent	Ash Per Cent
Full bloom . . .	17.86	4.04	18.39	52.28	7.43
Pods forming . . .	19.13	3.06	18.52	50.58	7.91
Pods formed . . .	21.38	5.01	29.05	32.59	11.97

We note from the table that in every constituent the percentage composition is higher when pods were formed than at any earlier time.

The leaves should be carefully guarded and harvested, for they contain about twice as much protein as do the stems. The Michigan Station found the following composition of leaves, stems and roots.

Percentage Composition of the Parts of Cowpea Plants

	Dry Matter	Protein	Nitrogen	Ash	Phosphoric Acid	Potash
Leaves . .	36	27.08	4.33	16.38	0.71	1.63
Stems . . .	36	17.83	2.87	12.40	0.65	3.32
Roots . . .	28	5.61	0.89	5.38	0.62	1.32

It may be seen from this table how important it is to save the leaves in harvesting. After cowpeas are cut and slightly cured, they may be put into small haycocks and there left to cure until the stems are sufficiently dry to prevent spoiling in the haymow or in the stack. One thing to guard against in haying is to prevent the leaves from matting together. In damp weather, cowpeas often mildew, but mildewed cowpea hay will not harm stock, and they will eat it — although its feeding value is somewhat reduced.

If cowpeas are harvested for seed, they are left to mature. The hand and the huller method are used in separating the seed.

Barnyard manures, commercial fertilizers, lime where the soil is sour — although cowpeas will grow in acid soil — and the rotation of crops are all essential factors in the production of cowpeas.

Uses of cowpeas. — The seeds of cowpeas are so extraordinarily nutritious that the countries of the Old World use them for human food. Beans of various kinds are substitutes used in the United States. Cowpeas furnish nitrogenous nutrients to a larger extent than the usual food. Their nutritive ratio is as 1 : 2.9, whereas a workingman requires food that has a nutritive ratio of about 1 : 8 or 1 : 9. Therefore, cowpeas must be supplemented with carbonaceous foods in order to properly balance the ration. Although cowpeas are used to some extent in the United States, it is to be hoped that their use will become more common for human food.

Cowpea hay is an excellent food for the dairy cow. It is closely comparable to wheat bran. Their digestible composition follows:

PERCENTAGE DIGESTIBLE COMPOSITION OF COWPEA HAY

	Dry Matter	Crude Protein	Carbo-hydrates	Fat	Total	Nutritive Ratio
Corn for comparison	89.5	7.5	67.8	4.6	85.7	1 : 10.4
Cowpea hay . . .	90.3	13.1	33.7	1.0	49.0	1 : 2.7
Bran	89.9	12.5	41.6	3.0	60.9	1 : 3.9

From this table it will be seen that cowpea hay contains more protein than bran, has a narrower nutritive ratio, but has about 12 pounds less total digestible matter. At the Alabama Station[1] it was found that 1720 pounds of wheat bran were equivalent to 2000 pounds of cowpea hay for milk production.

For beef production cowpea hay has been found to be exceptionally fine. The following from the Missouri Station[2] shows the results of cowpeas as compared to timothy hay for beef production.

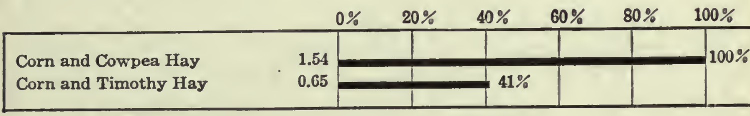
[1] Bulletin No. 123.
[2] Missouri Station, Circular No. 11.

COMPARISON OF COWPEA HAY WITH TIMOTHY HAY FOR WINTERING YEARLING STEERS

104 days — Four Steers in Each Lot — Four Pounds Corn per Day per Steer.

	Corn Eaten, Lb.	Hay Eaten, Lb.	Total Gain, Lb.	Average Daily Gain, Lb.	Grain per Lb. Gain
Corn and timothy hay	1568	6536	260	0.64	6.00
Corn and cowpea hay	1568	7757	624	1.54	2.51

The close study of this table brings out some interesting things. To represent the average daily gain graphically we have



The steers fed corn and timothy hay did 41 per cent as well as those fed corn and cowpea hay.

Cowpeas with corn as a feed have brought the following returns in pork production at the Missouri Station:

RESULTS WITH CORN AND COWPEA FORAGE[1]

Year	Number Days Pastured	Number Hogs per Acre	Pounds Gain per Acre	Pounds Gain Accredited Forage	Value of Forage per Acre. Pork @ 6¢ per Pound
1909	30	10	568	568	$34.08
1910	57	12	276	276	16.56
1911	28	10	140	140	8.40
1912	24	24	314	314	18.87
Average . .	$34\frac{3}{4}$	14	324.5	324.5	$19.48

The results were obtained by hogging down corn and cowpeas. Besides the return in production of pork, the practice of

[1] Bulletin No. 110.

"hogging down corn and cowpeas" is a simple and effective means of preparing the field for tillage and of adding to its fertility.

Summary. — The cowpea, originated and developed by China and India, is an important agricultural contribution to the world. It is important because as a soil builder, and as a nitrogenous feed, it has few equals. The factors that help to increase the

Courtesy College of Agriculture, Columbia, Mo. Bulletin No. 110.

Fig. 62. — An abundance of forage from cowpeas. Cowpeas fit well into a rotation, having the double value of conserving fertility and supplying abundant pasturage.

yield and usefulness of cowpeas are proper culture, use of the variety suited to the local conditions, harvesting at the proper time, and the use of barnyard manures and fertilizers. Cowpeas are used for human food, and as a hay and forage crop. Cowpea hay is scarcely excelled by any other hay. This is especially true if it is used as a feed for cattle and sheep. Growing of cowpeas may be well encouraged.

QUESTIONS

1. Narrate the history of cowpeas.
2. What are the advantages of growing cowpeas?
3. What are the main factors that will help to increase the yields of cowpeas?
4. What are the chief uses of cowpeas?
5. What is the difference between New Era and Whippoorwill cowpeas?

PROBLEMS

1. Report upon the varieties of cowpeas grown in your locality. Bring some plants of each variety and discuss the characteristics of each.

2. Compare the composition and feeding value of cowpea hay and timothy hay; cowpea seeds and corn.

REFERENCES

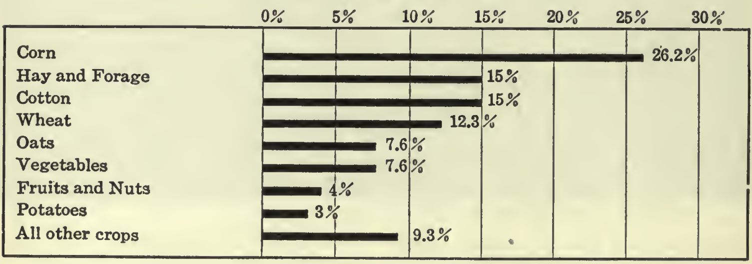
Piper, Forage Plants and Their Culture.
Henry and Morrison, Feeds and Feeding.

CHAPTER X

HAY PRODUCTION

Value of the hay crops. — Hay and forage crops in 1909 occupied 15.1 per cent of all improved lands of the United States (72,280,000 acres) and contributed 15 per cent of the total value of all crops. The value of the hay and forage crops was $824,000,000. The following is the comparative value of the great farm crops as given by the census of 1910. The per cent of the total value of all crops is given.

RELATIVE VALUE OF FARM CROPS, 1910



From the data given it may be observed that hay and forage crops and cotton tie for second place in the value of all crops produced. The average acreage yield of hay and forage for 1909 was 1.35 tons, valued at $8.46 per ton.

Advantages of timothy hay production. — Approximately 60 per cent of all the hay crops is timothy. The advantages of timothy may be stated as follows: (1) Timothy grows for several years without reseeding; (2) Timothy yields fairly well; (3) Timothy seed is usually comparatively cheap; (4) Timothy stands up

well and seldom lodges; (5) Timothy is easily cured; and (6) Timothy makes a good horse feed.

Advantages of a mixture of hay crops. — A mixture of timothy and red clover for a hay crop, or even better, a mixture of timothy and Mammoth clover, which matures at about the same time timothy does, has the following advantages:

1. The root systems of clover and timothy differ in their feeding habits; timothy feeds near the surface and clover penetrates deeper into the soil. The root systems utilize plant foods from different strata of the soil.

2. The food requirements of these two plants vary somewhat; therefore the two plants can secure a greater amount of plant foods from the soil.

3. The clover, being a legume, stores free nitrogen from the air in the soil. Since nitrogen makes for luxuriant growth, more timothy is produced because of the nitrogen gathering quality of clover.

4. The feed produced is more nearly a balanced ration than timothy alone. The clover contains more nitrogen, as the following table indicates.

PERCENTAGE DIGESTIBLE COMPOSITION

	Dry Matter	Crude Protein	Carbohydrates	Fats	Total Digestible	Nutritive Ratio
Timothy . . .	88.4	3.0	42.8	1.2	48.5	1 : 15.2
Red Clover . .	87.1	7.6	39.3	1.8	50.9	1 : 5.7

Notice that the nutritive value of red clover is as 1 : 5.7 and of timothy it is 1 : 15.2. The combination of clover and timothy is far superior to timothy hay alone.

Culture of hay crops. — Timothy is generally sown in the fall, preferably with wheat in a well-prepared seed bed. If clover is sown it is usually sown in the spring in the growing wheat. From ten to twelve pounds of timothy seed are sown per acre if sown

alone. If timothy and clover are sown together, a mixture of six pounds of timothy and six pounds of clover may be sown. Neither clover nor timothy should be sown very deep. A good general rule to follow in planting any seed is to plant it at a depth five times the diameter of the seed.

Timothy fields may be pastured profitably, especially where the aftermath is abundant, for pasturing aids in packing the soil. The condition for growth is thus improved. Several pounds of live weight may be put on from this feed which otherwise would be a waste product. The meadow must not be grazed too closely in the fall, for this will materially reduce the yield the following year. When stands of meadows get thin, they may be rejuvenated by applying barnyard manures or commercial fertilizers.

Harvesting the hay crop. — Crops are harvested for their grains, their stems and leaves, or for all three. Wheat is harvested for its grains, corn in the case of silage for stems, leaves and ears, and timothy is harvested for its stems and leaves.

The proper time to harvest a plant is when it combines the following three qualities: (1) When it yields the most feed; (2) When it will yield the most digestible nutrients; (3) When it will cure so that it is most palatable.

These points have been determined by an experiment carried on at the Missouri Station[1] from which the following data were secured.

YIELD OF TIMOTHY CUT AT DIFFERENT STAGES OF MATURITY

	Dry Matter, Lb.	Crude Protein, Lb.	Carbo-hydrates, Lb.	Fat, Lb.	Total Digestible Matter, Lb.
Coming into bloom	3411	135	1676	43	1908
Full bloom . . .	3964	147	1867	44	2113
Seed formed . .	4089	113	1802	51	2030
Seed in	4038	98	1695	54	1914
Seed ripe . . .	3747	92	1576	38	1754

[1] Proc. Soc. Prom. Agr. Science 1910.

It will be observed from the table that more dry matter may be secured by cutting timothy when the seeds are formed, but that more digestible protein, carbohydrates and total digestible matter may be secured in harvesting when timothy is in full bloom.

It was also found in the same experiment that where cattle had free access to the feed racks containing each of the above cuttings, they invariably chose the hay from the first three cuttings and discriminated sharply against the fourth and fifth cuttings. The palatability of timothy is greater when cut in full bloom or about that time than when the seeds are well formed or when the seed is ripe. No plant should be cut or stored when it is so dry that it will not pack well. Putting hay in the stack or in the haymow when it is still a little green will not harm the hay, but will improve it.

Feeding value of timothy hay. — Timothy hay feeding value is very similar to prairie hay and Sudan grass hay. Its feeding value, according to experiment, is not so high as that of clover or alfalfa. This is proved by the following table, showing the digestible composition of a few of the hay crops.

PER CENT DIGESTIBLE COMPOSITION

	Total Dry Matter	Crude Protein	Carbohydrates	Fats	Total Digestible Matter	Nutritive Ratio
Timothy	88.4	3.0	42.8	1.2	48.5	1 : 15.2
Prairie Hay	93.5	4.0	41.4	1.1	47.9	1 : 11.0
Alfalfa	91.4	10.6	39.0	0.9	51.6	1 : 3.9
Red Clover	87.1	7.6	39.3	1.8	50.9	1 : 5.7

Note from the table that the total digestible matter, the fats, and the carbohydrates in the four hays are nearly alike; but that alfalfa and red clover furnish more protein, hence their nutritive ratio is much narrower.

At the Illinois Station,[1] with ten cows in each of two lots, over a period of 131 days, the following results were secured.

[1] Bulletin No. 159.

They contrast the value of timothy hay and clover for milk production.

CLOVER *vs.* TIMOTHY HAY FOR MILK PRODUCTION

	Nutritive Ratio	Average Daily Yield	
		Milk, Lb.	Fat, Lb.
Ground corn 3.3 pounds Gluten feed 4.7 pounds Clover hay 8.0 pounds Corn silage 30.0 pounds	1 : 6	30.1	0.90
Ground corn 8 pounds Timothy hay 5 pounds Clover hay 3 pounds Corn silage 30 pounds	1 : 11	20.5	0.69

At the Illinois Station the value of timothy hay and alfalfa hay as feeds for work horses was determined. It was found that, in order to maintain the weight of the horses, less grain was required by the horses that were fed alfalfa. A saving of 22 per cent of grain in favor of alfalfa was the result of the experiment.

For sheep, beef steers and swine, as well as for dairy cows and work horses, clover hay has proved invariably superior to an equal amount of timothy hay. Timothy and prairie hay are held in high favor because they are usually comparatively free from dust. Dusty hay is one of the principal causes of heaves in horses.

Summary. — Hay and forage crops tied with cotton for second place as a money value crop in 1909. The important hay plants are timothy, alfalfa, red clover and others. The legume crops are growing in popularity. They are high in protein, have a narrow nutritive ratio and are excellent feeds in balancing a carbonaceous ration. Hay crops should be harvested when they yield the most digestible nutrients. Besides growing roughages

in permanently established hay fields the growing of catch crops and hay crops upon temporarily idle fields is to be encouraged, for it protects the soil while the crop is growing and provides additional feed.

QUESTIONS

1. What is the importance of the hay crops of the United States?
2. What are the advantages of the production of hay crops?
3. What are the advantages of a mixture of hay crops to the production of a single hay plant?
4. What is the best time to cut timothy for hay? Why?

PROBLEMS

1. Report upon the comparative yield, composition and feeding value of timothy, alfalfa and red clover hay.

REFERENCES

Piper, Forage Crops.
Henry and Morrison, Feeds and Feeding.
Bailey's Cyclopedia, Vol. II.

CHAPTER XI

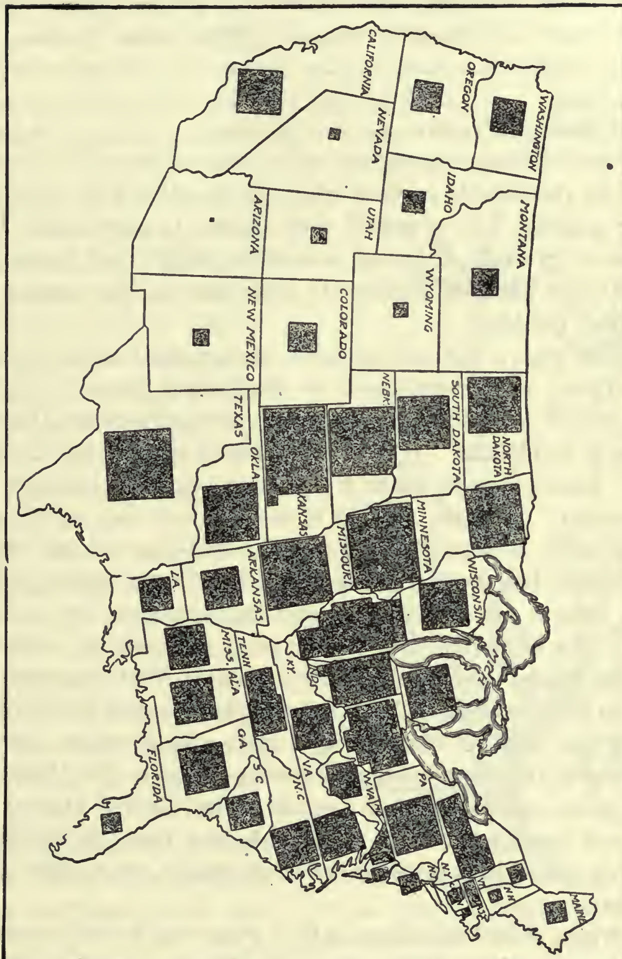
PASTURES

Importance of pasture crops. — Beef, pork, mutton, wool, milk and horseflesh energy are more cheaply produced upon pasture crops than on any other feed. It costs from 20 to 50 cents per day during winter to feed 1000 pounds of live weight, but the same product may be maintained upon pasture grasses at the rate of from two to ten cents per day. The cheapest gains on beef steers, porkers and sheep are produced on pastures. Were it not for this fact we would have to pay much more for our meat. Sheep and beef production depend upon wide ranges of pastures. Wool would be much higher in price if the great states of the West did not provide so much pasture land.

Besides the regular pasture lands, other fields furnish pasture crops that can be utilized in certain seasons. The grass grown in wheat and oat fields after these crops have been harvested furnishes excellent pasture. The aftermath in meadow fields also provides an abundance of pasture. Although the stalk field cannot be exactly regarded as a pasture crop, it, too, furnishes a great deal of feed. All these crops would be practically waste products, were they not utilized by grazing animals. All of the above named feeds are cheap, because little labor is expended in their production. Investigations have shown that the greatest profits in live stock production have been made where these cheap feeds have been utilized.

Pasture plants. — The chief pasture plants are blue grass, white clover, red top, Bermuda grass, and alsike clover.

Blue grass. — Blue grass is the milk of the pasture plants because it is very similar to milk in composition. The percentage composition of blue grass and milk is given on page 162.



Courtesy Literary Digest.

FIG. 63. — According to the 1910 census there were 400,346,000 acres or 45.6 per cent of unimproved land in the United States. Much of the unimproved land furnished good grazing.

Percentage Composition of Blue Grass and Milk

	Water	Protein	Carbo-hydrates	Fat	Ash	Nutritive Ratio
Cow's Milk . .	86.4	3.5	5.0	4.4	0.7	1 : 44
Blue Grass . .	68.4	4.1	23.5	1.2	2.8	1 : 70

The above table explains why blue grass has such excellent feeding qualities. It is indeed very similar to cow's milk, the most nearly universal, and most nourishing, single food known to man. No single plant is superior to blue grass in its capacity to yield animal products.

Blue grass is the most common pasture grass in the northeastern, southern, and central parts of the United States. By its habit of growth and by its persistence it often drives out timothy, red clover, and alfalfa. It grows best in early summer and late autumn.

"Kentucky blue grass is the most important pasture grass in America. It grows best in a moist, limestone, rather compact, firm soil. It grows in every section and state of our nation, but it thrives best in the regions where corn, oats, timothy and wheat are grown. It is shallow rooted and therefore does not do well in a dry or porous soil. Blue grass increases or reproduces by underground stems and is very hardy. Tramping and grazing seem to aid in causing this wonderful plant to yield its best results."[1]

White clover. — Next to blue grass and Bermuda grass, white clover is the most important pasture grass in the United States. It grows extensively from Canada to the Gulf of Mexico. White clover propagates itself from seeds and from its trailing vines. Each vining stem grows roots at the joints, from which grow new plants.

White clover supplements blue grass just as red clover supplements timothy. White clover is richer in protein and helps to balance the ration for all kinds of live stock.

Red top is adapted to moist, wet, acid soils, and will grow in

[1] Paragraph quoted from the author's book, Productive Agriculture.

places where blue grass and white clover refuse to grow. Red top is a better pasture plant than a hay plant, and ranks about third or fourth among the important perennial grasses. It is not generally sown except in soils that are too heavy, wet, or acid for timothy, red clover, or blue grass. Its feeding value as a hay is about equal to that of timothy hay.

Bermuda grass is to the Southern States what Kentucky blue grass is to the Northern States. It is adapted to almost any kind of soil, but makes its best growth in well-drained, black loam, bottom soils. Bermuda grass provides a great deal of pasture, and should be closely grazed to get best results, as the stems get large and fibrous when permitted to grow to any size. Bermuda hay has about the same feeding value as timothy hay.

FIG. 64. — Bermuda grass. (*a*) spikelet; (*b*) floret.

Alsike clover is adapted to wet, even water-logged soils. Where red clover dies on account of "clover sickness," alsike will thrive. It will grow in an acid soil where neither white nor red clover will grow. Alsike is larger than white clover. The culture of alsike is like that of red clover. The rate of seeding is eight to twelve pounds per acre.

Pasture mixtures. — Planting a mixture of pasture grasses usually gives better returns. A fair mixture of grass seed to sow per acre is the following:

Blue Grass	6 pounds
Red Top	3 pounds
White Clover	3 pounds
Alsike	$1\frac{1}{2}$ pounds
Red Clover	3 pounds

The important advantages in growing a mixture of pasture grasses are:

1. The roots of the plants feed at different depths of the soil, and therefore more plant foods are exposed to their root systems.

2. The legumes in the above mixture gather free nitrogen from the air and store it in the soil. This makes for a more luxuriant growth of the grasses.

3. The mixture of pasture grasses mature at different seasons. Blue grass thrives in early spring and late fall. The clovers are in their glory in midsummer. Maturing at different seasons distributes the feed throughout the growing season.

4. A mixture of pasture crops helps to balance the ration, as may be seen from the following table, showing the percentage digestible composition of the main pasture grasses:

Percentage Digestible Composition of Pasture Grasses

Plant	Dry Matter	Fat	Carbohydrates	Protein	Nutritive Ratio
Blue Grass . . .	31.6	0.6	14.8	2.3	1 : 7.0
Red Top	39.3	0.6	20.0	1.9	1 : 11.3
White Clover . . .	21.8	0.5	9.6	3.1	1 : 3.5
Alsike	21.5	0.4	10.4	2.3	1 : 4.9
Bermuda	33.2	0.5	17.0	1.4	1 : 12.9

It may be readily seen from the above table that the legumes are comparatively rich in protein. White clover and Alsike have a fairly narrow nutritive ratio, while the grasses have a wider nutritive ratio. About 60 per cent blue grass and 40 per cent white clover make an ideal ration for any live stock.

5. A mixture of plants will fit different soil conditions. Blue grass and white clover demand a fairly well-drained, sweet soil, —

preferably a limestone soil. Red top and alsike will do very well in a damp, wet soil, which may be acid.

6. Different plants require different amounts of light. Blue grass does fairly well in shady places. The other pasture plants require more sunshine.

There is no single plant that will produce better yields of animal life than blue grass; but that blue grass and some legume plant will bring better, larger, and more economic returns remains unquestioned.

Temporary Pastures. — *All year pastures.* — The best farmers of our country attempt to provide green succulent feed for swine, sheep, dairy cattle and poultry if possible every day in the year. Of course corn silage is an excellent succulent feed in summer during a shortage of grass as well as in winter.

But the pasture crops that we would refer to in this section are composed of such plants as the following:

1. Rye for fall, winter, and spring.
2. Oats and Canada field peas for spring and early summer.
3. Rape and vetch and oats for fall.
4. Rape, oats, and cowpeas in spring.
5. Oats and wheat for fall.
6. Cowpeas or soy beans for summer, plus the regular pasture crops.

At the University of Missouri a bushel of corn yielded on an average 66 cents worth of pork, but with the pasture and forage crops it yielded $1.10 worth. In other words a bushel of corn produced almost twice as many pounds of pork when it was supplemented with a pasture or forage crop. In the above figures pork was sold at 6 cents per pound.

Yields of pastures. — Plants make a very long growth in one season. It is said that if four average crops of alfalfa harvested from one field could be placed above one another as they grew in the field they would make a height of 12 to 15 feet. Blue grass would not reach such a height in one season, but it is very dense. It forms a veritable mat, even so thick that Dean Henry found

at the Wisconsin Station[1] that 3.7 acres of excellent blue grass pasture kept three cows for 122 days. Will 3.7 acres of any other crop keep three cows for 122 days, with as little labor as is required on a pasture?

Management of pastures. — Very little time or work is spent upon pastures. It is a common belief that pastures will do well without any care or labor. However, it may be safely stated that if farmers would spend one-half as much time per acre upon their pastures as they do upon the production of corn or wheat, much better results would be secured.

FIG. 65. — The amount of food, starches especially, that a plant can manufacture depends directly upon the amount of leaf surface exposed to the sun.

Pastures are often grazed too early in the spring and too late in the autumn. Early spring grass is soft and watery, and has little feeding value. Early grazing stunts the growth of the grass for the entire season. However, after the roots of the pasture plants have attained their normal size and number in the early spring the large root surface will be conducive to a rapid, continuous, and abundant growth, throughout the entire growing season even if heavily grazed. It is more economic in the management of the farm to continue feeding into the spring months. Legume hay and corn silage may be fed in early spring, or even in midsummer during a shortage of pasture grasses.

Permitting grass to get too large indicates insufficient pasturing. When the grass plants get large, the stems and leaves begin to bleach near the surface of the soil. The bleached grass is semi-dead and does not manufacture any more food elements. Plants manufacture the most food when the maximum amount of green leaf surface is exposed to the sunshine. The green chlorophyll

[1] Wis. Report 1885.

bodies in the leaves of plants are the only true manufacturers of starch in the world. The figure on page 166 is significant and in part explains the fact. For further information read a good text on Botany.

Pastures are often grazed when the ground is wet and soft. This is a poor practice, for tramping wet soil puddles it, and thus reduces its producing power. During such periods, when the soil is so wet that it will pack, feed corn silage and legume hay.

Weeds and shrubbery should be kept out of pastures, for they take room and rob the grass of plant foods, soil water and sunshine. Mowing the grass a few times through the season is time well spent. If a mower is used, it should be set high enough so that the grass itself is not injured. The weeds should be cut before they grow new seeds. Sheep and goats help to renovate pastures. Hogs should not be permitted to root up pastures.

Bare spots in pastures need re-seeding, light harrowing and a top dressing with manure. When commercial fertilizers are used, a nitrogenous fertilizer in the form of nitrate of soda of 150 to 200 pounds per acre is recommended. Occasionally a complete fertilizer is used having the following composition: nitrogen, 4 per cent; phosphoric acid, 12 per cent; and potash, 2 per cent. About 400 pounds are used per acre. All the pasture plants do better in a sweet soil, and some of them will not grow at all in an acid soil. Ground limestone applied in amounts of one to two tons per acre will correct the acidity.

Summary. — Meat and milk are produced most cheaply upon pasture grasses. Wide acres of our land are suited only to pasture grasses, and our appreciation of the value of these lands when so used may be increased. Blue grass and white clover, red top and alsike clover, and Bermuda grass are the important pasture grasses of the United States. These grasses are adapted to different soils and climatic conditions, and have different habits of growth; and therefore growing a mixture of these plants has several advantages. Many farmers are beginning to grow temporary pastures. The crops best adapted to temporary pastures are rape,

rye, oats, vetch, cowpeas, soy beans and wheat. Pastures are abused by grazing them too early and too closely and by not keeping down the weeds. The production of animal products through the pasture saves much labor.

QUESTIONS

1. Why are animal products produced so cheaply on pastures?
2. What are the chief pasture plants and what are the superior qualities of each?
3. Why grow a mixture of pasture plants?
4. How should pastures be managed in order to get most feed from them?
5. Make suggestions on the eradication of weeds and shrubbery from pastures.

PROBLEMS

1. Compare the composition and feeding value of the pasture grasses, as given in some text on feeds and feeding.

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CHAPTER XII

THE COTTON PLANT

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Geography. — The cotton growing section of the United States has been limited by climate to what is generally called the Southeast section. It is grown profitably in eleven States — North Carolina, South Carolina, Georgia, Tennessee, Florida, Alabama, Mississippi, Louisiana, Texas, Oklahoma and Arkansas, — and to a less degree in Missouri and Virginia. In the early development of the nation it was grown, and with profit, much farther north. The *American Farmer*, an old farm journal published in Baltimore, 1817 to 1830, reports in the 1820 edition that cotton was grown at that time in Sangamon County, Illinois, and it paid. It also reports that cotton was extensively grown in Maryland and New Jersey.

In more recent years the tendency has been to grow it in the restricted area as outlined above. That this is so is unquestionably due to fundamental climatic conditions as well as to agricultural economics. It can be grown farther north, but other crops are grown with greater profit in the more northern latitudes, and with greater certainty. Cotton is a warm weather or subtropical and tropical plant. It demands an abundance of sunlight, and even a light early frost will cut the crop short. Long summers and late autumns insure large cotton crops.

Historical. — Cotton was introduced into this country by the colonists. The great historian George Bancroft says: "The

first culture of cotton in the United States deserves commemoration. In this year (1621) the seeds were planted as an experiment, and their plentiful coming up was at that early day a subject of interest in America and England."

Whether the English or Spanish colonists brought and planted the first cotton on the continent of North America we are not sure, but there is evidence that it was introduced from the West Indies and from Mexico at a very early date.

Once introduced, the industry developed very rapidly. The value of cotton for clothing was well known thousands of years before America was settled, but it has grown in popularity very rapidly from that time. Cotton fiber is a crop which if kept protected from the weather does not spoil or decay, and from the beginning had a standard market value, determined largely by the world supply. It was also grown from the first both for home use and for its ready money value. In this country cotton and tobacco were the first crops to have an international market value, and this was one of the factors in promoting its growth among the colonists.

Three bags were shipped from Savannah in 1747, and 8889 bales of 225 pounds each were raised in 1791. As the trade grew the crop grew in importance, and the industry was limited only by man's ability to separate the seed from the lint.

The cotton gin. — We mention the gin here because the cotton industry could hardly have reached the immense proportions it has reached except for the *saw* gin which was invented by Eli Whitney in 1793, just at the beginning of George Washington's second administration.

In the oriental countries there was a small roller gin known as the *Ghurka*, consisting of two very small rollers about an inch in diameter mounted on frames with a crank at one end for turning. Its use was a very tedious and slow process, but superior to the hand method of picking the lint off the seed. This ancient type of implement was used for thousands of years, but it must be kept in mind that the cotton industry was a very insignificant

industry before the invention of the saw gin by Whitney. Since that time its growth has been nothing short of marvelous, and history records no parallel to it.

Species and varieties. — It is necessary to discuss the broader phase of species here before attempting to give an outline of the origin of the popular term "varieties," so commonly used in the sale of cotton seed for planting. Cotton was originally introduced into this country, both from the Mediterranean countries and from the West Indies and other tropical sections of the Americas. Investigation has shown, however, that the American species of cotton have long since supplanted the European species planted by the colonists in the early days. While the records are not complete on the elimination of the European and the introduction of the American species, we have for more than a century been planting two distinct American types — closely related if not the same species — and known as the short staple Upland (*Gossypium hirsutum*) and the Sea Island long staple (*Gossypium barbadense*). Scientists have agreed that these two types originated in the New World — the former probably in Central America and the latter in the West India Islands.

It is stated by many authorities that early planters from time to time received cotton seed from China and India, and that remnants of these Asiatic species or types are still to be seen in some of our varieties. The Russell big boll variety frequently shows a reversion to a primitive greenish lint type, and is called by some planters the Nankeen variety. Historians do not agree as to the explanation of this, and the subject is so broad and complex as to require special study. We refer the reader for further information to Sir George Watts's *Wild and Cultivated Cottons of the World*. To what extent our American varieties have been modified by introduced types from Asia, or whether they have been changed at all is a debatable question; but we shall study the commercial varieties now in existence in the United States as direct descendants of the two original American types of short staple Upland and Sea Island long staple. More than nine-tenths

of the American cotton crop comes from the former and less than one-tenth from the latter.

Types. — Of the Upland cottons we have eight fairly distinct divisions, as follows: Big boll, long staple, cluster, semi-cluster, early or short-limb, long limb, Peterkin or Rio Grande, and intermediate groups. Duggar, of the Alabama Station, gives the following classification:

(1) Cluster varieties or Dickson.
(2) Semi-cluster varieties or Peerless type.
(3) Rio Grande varieties or Peterkin type.
(4) Short limb varieties or King type.
(5) Big boll varieties or Duncan type.
(6) Long limb varieties or Petit Gulf type.
(7) Long staple Upland varieties or Allen type.

Of all these types, each one has some excellent point which adapts it to some peculiar condition under which it was originated. There is perhaps no best variety or type except for a given set of conditions, and even this may not be fixed. The farmer who succeeds with cotton will test the various types and find the one for which his land is best adapted.

Origin of varieties. — Out of these seven or eight types there have been evolved more than seven hundred varieties, many of which are only changes in name. These varieties have been produced in two ways — first, by *mass selection;* and second, by *isolation.* In the former the grower enriches his soil, and produces a good crop. In the early fall he goes through the field, selects several hundred stalks, picks the cotton from these and has it ginned separately. The seed from this selected cotton forms the basis for his new variety name.

The second method is the more reliable, in which a single selected plant is made the basis of the new variety. A select plant may be found in a field of any variety. It is selected because of some special point of excellence such as large bolls, long lint, prolificacy, and the like. The seeds are selected from this particular plant to be used as the basis of the crop the second or third year hence.

They are planted in a small area isolated from the general field of cotton in order to keep insects from crossing it with other varieties by taking pollen grains from flowers on one variety to those on another. Cotton is very susceptible to cross fertilization. By the second year this small patch may be made into a five or ten-acre field; and the third year, a hundred-acre field, which is the progeny of our one selected plant.

The distribution of varieties. — As soon as a leading farmer in a community succeeds with a variety of cotton his neighbors are after him for seed, and if they succeed with it all their neighbors want some of the seed; so within a very few years the variety becomes well distributed locally. Small advertisements of it are run in the farm journals and the newspapers, and through this medium seed is shipped to various parts of the cotton belt. If the originator happens to be a good business man and salesman, and has good cotton to offer, the variety can be made popular and will bring great prosperity to him. If, however, it does not prove a success, it is not often known outside of the community in which it originated.

Popular varieties in different states:

1. Alabama: Toole, Wanamaker, Cleveland, Cook, Express.
2. Arkansas: Allen's Big Boll, Black Rattler, Hawkins.
3. California: Durango, Mebane, Yuma.
4. Florida: King's Improved.
5. Georgia: Cleveland, Sunbeam, Cook, Broadwell, King, Triumph, Russell.
6. Louisiana: Wanamaker, Cleveland.
7. Mississippi: Kings, Jackson, Mortgage Lifter, Russell.
8. North Carolina: Cleveland, Wanamaker, Simpkins, Cook's Improved, Webber.
9. Oklahoma: Mebane, Triumph, Rowden, Lone Star.
10. South Carolina: Cleveland, Dixie Wilt Resistant, Hartsville, Keenan, Webber.
11. Tennessee: Trice, Cleveland.
12. Texas: Lone Star, Wanamaker, Peterkin, Mortgage Lifter, King's Improved.
13. Virginia: Trice, Triumph, Cook, King.

Importance of the cotton crop. — The American cotton crop is the greatest ready money crop in the world. Our corn crop has a greater money value, but not all of it is marketed. All our cotton crop is marketed before it is used or manufactured into cloth. More than 60 per cent of our corn crop never gets to market at all, but is consumed on the farms where it is raised. The 1918 cotton crop will likely be more than 12,000,000 bales and will have an estimated value of about $2,250,000,000. The price is high now, and this high valuation would not apply unless cotton was 30 cents per pound.

This large fiber crop constitutes more than 50 per cent of our clothing, and its use could hardly be dispensed with now without extreme inconvenience and positive discomfort. More than 10,000,000 persons are engaged in its production and about seven million more in manufacturing the raw fiber into fabrics.

Advantages of cotton production. — The fact that cotton is a ready money crop and can be grown under the greatest variety of farm conditions makes it very popular as a money crop. One has only to scratch the land, put in a few seed, and keep the weeds out and cotton is sure to follow. It pays well for careful planting and responds to a scientific agriculture as readily as any crop grown, but can also be raised under as unfavorable conditions as any crop.

If not harvested just at the time it is ready, it will wait till you are ready, though exposure to the weather lowers the quality and grade. After it has been harvested it may be left in storage for an indefinite time without any fear of deterioration. It keeps well, and without any effect whatever on its quality. It always has a standard market value, which generally fluctuates with the size of the crop or with the universal law of economics called *supply and demand.* Larger yields cause a fall in prices, while light yields cause a corresponding rise in market price. But it always has a ready money value and can be kept stored without any fear of deterioration till the most convenient time for marketing.

The cotton plant. — The cotton plant is a member of the mallow family along with okra and hollyhock. It is a perennial in tropical climates and an annual in cooler climates. As was stated in another paragraph, it is of the genus Gossypium and of the two species *hirsutum* (the short and long staple Uplands) and *barbadense* (the Sea Island).

The height of the plant depends upon the fertility of the soil, but ranges largely from a few inches to five, six and seven feet of the species grown in the Temperate Zone. In the Tropics, where it grows wild, it develops into trees 30 and 40 feet high and 10 inches in diameter near the ground.

FIG. 66. — A cotton plant.

The leaves are alternate and deep lobed. The branches or limbs are of two kinds, vegetative and fruiting. The vegetative branches are to be avoided in the selection of seed for improving a variety. On these there is no fruit except on the smaller secondary branches, while on the fruiting branches the flower stalk grows directly on the branch.

Yields per acre. — The yield of cotton per acre is determined by the fertility as well as the preparation and cultivation of the land. Good farming makes high yields, and poor farming low yields. The actual yields in the cotton belt range from one-fifth of a bale to over two bales per acre. On the poor sandy lands, where little attention is given to the work and where the entire management of the farm is left in the hands of the careless renter, the yields are very low; and such farming is not only unprofitable but costly. Cotton requires clear cultivation. Summer rains wash the soil away unless it is well prepared and

cultivated. If the land is not prepared to hold the water that falls on it, what runs off will take the best part of the farm with it.

How to improve yields. — The first thing is to prepare the soil. Break the land deep — pulverize thoroughly. A good seed bed is important. Cotton is very tender when it first comes up. Plant in rows about 3 feet and 6 inches apart and thin down to about 18 or 20 inches apart in the row, leaving two plants to the hill. Experiment has shown this to be about the best possible average for distances and number of plants per acre.

Cover seeds only about an inch and press the soil down on them with a weight following the planter. Plant as early as possible after danger from frost is over.

Cultivate as early as possible. Do not wait for the young plants to come up, if the ground is crusted by heavy rains. Scratching the surface will help to get a stand, a very necessary thing.

Rotate cotton with corn and soil building crops. The land should not be in cotton oftener than once in three years. The following is a good rotation for cotton:

	First Year	Second Year	Third Year
First field	Cotton	Corn	Small grain followed by cowpeas
Second field . . .	Corn	Small grain followed by legumes	Cotton
Third field. . . .	Small grain followed by legumes	Cotton	Corn

Seed selection. — One of the essential things in increasing yield is the selection of good seed. This alone has been known to increase the yield as much as 30 per cent in one year. It will not average this, but seed selection will always help to increase

the crop. The following method suggested by Dr. Webber is very good.

First Year	Second Year	Third Year	Fourth Year	Fifth Year
Select plant	500 plants	5 acres	General crop	{ }
	Select plant	500 plants	5 acres	General crop
		Select plant	500 plants	5 acres
			Select plant	500 plants
				Select plant

This is a continuous process by which the best of the crop will be going into improving the strain all the time. Notice from the table that the new plants are always taken from the selected plants of the previous year.

Fertilizers and manures. — The use of fertilizers and manures with cotton has become a well-established custom east of the Mississippi; and the money value of the custom is so marked that it has extended to Arkansas, parts of Oklahoma, Louisiana and Texas, west of the Mississippi. Cotton draws heavily on the land for nitrogen, potash and phosphorus; and in applying fertilizers regard for its needs must be considered. Experiment has shown that it gives excellent returns on as much as a thousand pounds of high grade fertilizer per acre. Besides, the effect of the fertilizer is almost as noticeable on the following crop as it is on the cotton. Barnyard manure should be applied to cotton when possible. The water holding capacity of the soil is improved in this way. The plant food in the manure also helps to improve the crop, though this is perhaps the smallest return from farm manure on cotton.

Enemies of cotton. — Cotton enemies are divided into two general classes — *fungous diseases* and *insect enemies.* Bacteria

may play some part, but certainly very little economically. The *bacterial blight*, while in almost every field of cotton; causes very little damage in most cases.

We can only mention here the enemies of cotton by name: The fungous diseases are *cotton wilt*, *anthracnose*, *cotton rust*, *damping off* or *soreshin*, *root rot*, *areolate mildew* and *cotton leaf blight*.

The insect enemies are the *cotton boll worm*, *Mexican boll weevil*, *cotton caterpillar*, *cotton red spider*, *cutworm* and *nematodes*.

The best way to control most of these pests is by selection of seed free from disease and insect enemies, and by rotation. The boll weevil is of so much importance that we devote a special paragraph to it.

Control of boll weevil. — The following measures will help to control the boll weevil: (1) Destroy stalks early in the fall; (2) Burn stalks if badly infected; (3) Pasture cotton — cattle will eat many of the weevils; (4) Plant on well-drained land; (5) Plant early varieties, and plant them early; (6) Cultivate often; (7) Rotate the crop every year to land some distance from the field of the last year; and (8) Pick weevils off by hand before the season is well advanced and they become numerous.

FIG. 67. — Cotton boll weevil and larva (enlarged).

Harvesting cotton. — If cotton is left in the field during stormy, rainy weather the quality will be cut down and the price will be reduced accordingly. If the cotton is left exposed to the weather for any length of time after it is picked it will lose its brilliant silky color, and be reduced in grade and price. Cotton should be harvested as quickly as possible after the bolls are well opened, — as every cotton farmer knows. This will insure a clean crop and the highest prices. For the best effect it should be stored a

few days before it is ginned. This seems to develop quality that can be secured in no other way, though there is much speculation as to why this is so.

Cotton classification. — This is known in market places under the name of grading, and is an important process in buying and selling. Different grades have different values, and one must know the grade in order to know its value. The standard of classification is based on *middling*, which is the average or middle

FIG. 68. — Picking cotton on a plantation in Arkansas.

grade, — about halfway between the poorest and the best. Prices are fixed by, and quotations are based on, this grade.

In the early history cotton was classed largely by the country from which it came and was sold by sample. This custom established confidence between traders who afterwards received consignments by such common names as Fair, Middling, Ordinary, and Low. These names were taken literally at the time they were first used but have later come to signify trade names for cotton of definite look and value — of a definite color and amount of trash. The names adopted in the trade, a history of which we need not give here, are as follows:

Fair,
Middling Fair,
Strict Good Middling,
Good Middling,
Middling,
Strict Low Middling,
Low Middling,
Strict Good Ordinary,
Good Ordinary,
Ordinary.

This classification was adopted for short staple Upland white cotton at New Orleans in 1875 and the same incorporated in the official types adopted by the United States Department of Agriculture in 1914, except the names " Fair " and " Ordinary " were left off.

The differences in price of the various grades depend on the value of *Middling* and the demand for higher or lower grades. In 1913 the following differences were quoted on the markets:

Middling Fair 1¢ above Middling.
Strict Good Middling, $\frac{3}{4}$¢ above Middling.
Good Middling $\frac{9}{16}$¢ above Middling.
Strict Middling $\frac{1}{4}$¢ above Middling.

Middling Basis

Strict Low Middling $\frac{1}{4}$¢ below Middling.
Low Middling $\frac{1}{2}$ to $\frac{5}{8}$¢ below Middling.
Strict Good Ordinary $\frac{7}{8}$ to 1¢ below Middling.
Good Ordinary $1\frac{3}{16}$ to $1\frac{5}{16}$¢ below Middling.

Use of cotton. — Mention has already been made of the use of cotton as a fiber when made into fabric. It has many uses in addition to this. The fiber is almost pure cellulose and is easily converted into nitrocellulose compounds. Much of it is therefore made into explosives, especially the inferior grades and linters that come from the seed. It is also dissolved and spun into artificial silk, made into viscose celluloid and artificial India rubber.

The seed now furnish large quantities of oil that is made into olive oil, butterine, cottolene (lard), salad oils, oleomargarine and various compounds. The meal is a highly concentrated feed for animals. It is one of the richest of the protein feeds. The meal is also used in commercial fertilizers as a source of nitrogen. This meal has been used to a limited extent as human food and has possibilities in that direction. The hulls are now used mostly as feed for cattle and sheep.

QUESTIONS

1. What are the cotton producing states and why?
2. Briefly trace the history of cotton.
3. Compare the value of the cotton crop with other farm crops.
4. What are the advantages of the production of cotton?
5. Discuss the factors which will help to increase the yield of cotton.
6. How may cotton be improved?
7. Describe the cotton boll weevil and discuss the damage it does.
8. Discuss the factors that will help to combat the cotton boll weevil.
9. Discuss any recent methods of control and eradication of the cotton boll weevil.

PROBLEMS

1. How many plants to the acre would there be if cotton rows were put 3 feet apart and the hills in the row 18 inches?

2. It takes about 100,000 bolls of the average Upland to make a bale. With the above number of plants to the acre, how many bolls to the plant would be required to grow a bale to the acre?

3. A mote is an imperfectly developed seed. A poor variety of cotton averages 2 motes to the boll and this cuts down the value of the fiber about $1\frac{1}{2}$ %. How many motes would be in a bale of cotton according to above calculation? How many if there were 3 motes to the boll?

4. If a bale of good lint cotton is worth $140.00, what would these motes cost the farmer according to the above calculation? Careful selection of seed is the only way to get rid of motes.

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SECTION II. FARM ANIMALS

CHAPTER XIII

ADVANTAGES OF ANIMAL HUSBANDRY

Animal husbandry and permanent agriculture. — Animal husbandry has its disadvantages as well as its advantages. It is not the purpose of this chapter to urge every farmer to be a large producer of stock. Nor would we have any one infer that animal husbandry is the only means of maintaining the fertility of the soil, for there are other farm practices which may do this; but it is the purpose of this chapter to set forth some of the advantages of animal husbandry, and to show how animals help to make our agriculture more prosperous and permanent. We have robbed the soil too much and too long. It behooves us to resort to those farm practices which maintain and increase the permanency of our agriculture. Some of the advantages and benefits accruing from animal husbandry farming are:

1. Animals help in maintaining the fertility of the soil.
2. Animals utilize cheap feeds and waste products.
3. Animals help in establishing better systems of crop rotation.
4. Animals are manufacturers.
5. Animals help to distribute labor.
6. Animals enable the farmer to make more constant use of his capital.
7. Animals provide food and work.
8. Animals help in making nations great.

1. *Animal husbandry tends to maintain the fertility of the soil.* The production of grains and the removal of a crop year after year slowly but surely reduce the producing powers of the soil. Many

fields have been cropped so long that they produce much smaller yields than they did in their virgin condition. When crops are removed from fields, the following amounts of elements per ton are taken from the soil.

FERTILIZING INGREDIENTS, FERTILITY AND MANURIAL VALUE PER TON

	Nitrogen Lb.	Phosphoric Acid, Lb.	Potash, Lb.	Fertility Value per Ton	Manurial Value per Ton
Dent corn, grain	32.4	13.8	8.0	$ 6.85	$ 5.48
Wheat	39.6	17.2	10.6	8.83	6.74
Oats	39.6	16.2	11.2	8.42	6.74
Timothy hay	19.8	6.2	27.2	5.20	4.16
Red Clover hay	41.0	7.8	32.6	9.36	7.49
Oat straw	11.6	4.2	30.0	3.78	3.02
Corn silage	6.8	3.2	8.8	1.81	1.45
Cotton seed meal (choice)	141.2	53.4	36.2	29.63	23.70

Nitrogen in the above table is valued at 18 cents per pound, phosphorus at 4.5, and potash at 5. A ton of dent corn removes 32.4 pounds of nitrogen, 13.8 pounds of phosphorus and 8 pounds of potash. Every crop removes plant foods.

When animals are taken off the farm they also carry soil fertility with them in the following amounts:

FERTILITY REMOVED PER TON OF LIVE STOCK AND THEIR PRODUCTS

	Nitrogen, Lb.	Phosphoric Acid, Lb.	Potash, Lb.	Fertility Value per Ton
Fat pig	35.4	13.0	2.8	$ 7.10
Fat ox	46.6	31.0	2.6	9.96
Fat sheep	39.5	20.8	2.9	8.17
Milk	11.6	4.0	3.4	2.43
Butter	2.4	0.8	0.8	0.51
Wool	108.0	1.4	112.4	26.00

Fat pigs remove 35.4 pounds of nitrogen, 13.0 pounds of phosphoric acid, and 2.8 pounds of potash, per every ton of pigs taken off the farm.

Since it requires from five to six tons of corn to produce a ton of pork, and from ten to eleven tons of corn to produce a ton of beef; and since a ton of corn or swine or beef removes about the same amount of fertility, it is evident that the fertility in the rest of the corn not stored in these animal bodies is returned to the soil, where it is fed.

It has all been summed up in the following statement:[1] "A farmer selling hay sells in the form of fertilizer value one-half as much as he receives; if he sells pork he receives twenty times as much for it as the value of the fertilizers contained in it; if milk, forty times; and if butter, one thousand times."

Henry and Morrison[2] put it thus: "Seldom have farmers realized that every ton of grain sold removes from seven to eight dollars' worth of fertility. The loss through such mining of the soil is gradual but in a comparatively few years there will result none the less fields lacking in plant food and humus, which must ever afterwards be fed with fertilizers to secure fair crops. On the other hand, if a part of the crops are fed to live stock and proper care taken of the resulting manure, most of the fertility may be retained on the farms and the need of commercial fertilizers long delayed. Under extensive stock farming where more or less feeding by products rich in fertilizing constituents are usually purchased and fed on the farm, the land will even become richer and more productive year by year with but little need of commercial fertility."

Of all the plant foods consumed by animals, about 80 per cent of the fertilizing ingredients in the feed is returned to the soil in the manurial product. This shows that live stock farming conserves the fertility of the soil to a much greater extent than grain farming.

[1] Burkett — *Feeding Farm Animals.*

[2] Henry and Morrison — *Feeds and Feeding*, Chapter on "Barnyard Manures."

2. *Animals utilize cheap feeds and waste products.* — The extensive pastures and plains of the United States, the lands along streams and fences, the hillsides, the weeds and shrubs, the wheat screenings at threshing time, the grasshoppers and other insects, skim milk and sour milk, the grains in digestive residues in feed lots, the aftermaths in meadows, cornstalk fields, old oat and wheat straw stacks, table scraps, the waste products at butchering time — all of these and other feeds are cheap feeds

Fig. 69. — Utilization of cheap feeds. The cattle in the above picture were maintained through the winter on an old straw stack.

and are transformed into meat, milk, wool, work, or eggs at very little cost. It is these cheap feeds that produce high-priced products cheaply. Feeding high-priced grains is not always profitable, but feeding cheap feeds can seldom result in great loss. We do not advocate the production of cheap feeds, but we would emphasize the fact that oftentimes the cheap waste feeds about the farm and home are not utilized as well as they might be, and that one way in which animals may be produced at a greater margin of profits is by the use of otherwise waste feeds.

The factories produce many by-products; from the milling industry come wheat bran and shorts; from the creamery industry, buttermilk; from the packing houses, tankage, and meat scraps; from the cheese factories, whey; from the cotton factories cotton-seed meal, cotton-seed oil and cotton-seed cake. All of these by-products are made into splendid feeds — high priced, but very valuable in balancing the ration.

3. *Animals help in establishing better systems of crop rotations.* Horses eat oats; dairy cows need corn silage and clover, alfalfa, or soy beans; beef cattle need grass corn silage, and cotton-seed meal; hogs need corn and some pasture and forage crops; sheep need grass, a little grain and clover hay; poultry need corn, wheat, oats and some meat product. These needs of farm animals clearly point in the direction of diversified farming, in which a definite system of crop rotation may be practiced. Pastures, hay crops, cereals and legumes are all needed to feed the different farm animals.

A 160 acre farm divided into 4 fields of 30 acres each and leaving the other 40 acres for the farmstead and a pasture, makes a very good basis for crop rotations. On such a farm a six-year crop rotation may be practiced in which the crop rotation of one field is moved to an adjoining field every sixth year. Every 24 years a complete cycle is made. Rotating cereal, hay and legume crops may be practiced, so that well-balanced rations are produced for the different farm animals, and so that the fertility of the soil is maintained to the highest possible degree. The 30 acres of wheat grown is a cash crop.

4. *Animals are manufacturers.* — Animals convert raw products into fine finished products. The raw products because of the bulk and because of their relative low value cannot be marketed profitably a long way from home. It costs as much, or more, to ship a pound of hay to New York as a pound of butter. In the one case the cost of shipping would exceed probably the value of the product shipped; and in the other case it would be about five to ten per cent of the product shipped.

The following facts in a general way indicate the manufacturing capacity of various farm animals:

Animal	Feed	Amount of Product Produced	Approximate Value
Dairy cow	Corn silage, 30 lb. Alfalfa, 10 lb. Corn, 6 lb. Bran, 2 lb. Water, 75 lb.	25 lb. milk test 4% or one pound butter fat	45 cents
Swine	5-6 pound corn	1 pound pork	15 cents
Sheep	8-9 pound corn	1 pound mutton	12 cents
Steer	10-11 pound corn	1 pound beef	12 cents

Pork, beef, eggs, butter and wool are needed in New York, London and other cities of the world. Corn, hay and other feeds can be grown in the Mississippi Valley in abundance. Shall we ship the raw feeds to those points and feed it there or feed it at home and ship the finished manufactured article?

We may say that grains may be transported short distances, farm animals somewhat farther, and products that are worth twenty to thirty cents per pound may be shipped almost anywhere in the world. Animals are wonderful factories, reducing the pounds of raw products into fewer pounds, and thereby helping wonderfully in meeting the costs of transportation. The home market for the raw products is usually the nearest railroad station, whereas the home market through live stock may become a far-off city. We should appreciate both of those markets, and the products that help in making them possible. Animals are the medium through which the distant city becomes the market of the waste feeds and other feeds commonly found on the farm.

5. *Animals help to distribute labor.* — The production of our crops usually limits the farm labor to a few months of the year. Growing two crops has a tendency to distribute labor. And growing all the crops needed for different farm animals where the fields are almost the same size, will mean practically constant

employment throughout the working season. The necessity of producing these various farm crops needed in animal husbandry distributes farm labor as much as crop production alone can do this; and the production of animals causes a further distribution of labor. Twenty dairy cows require from five to seven hours of work daily or about 1825 to 2250 hours yearly. Beef cattle do not require quite so much attention. Swine and sheep raising will also demand some attention the entire year. See the chapter on Farm Labor for further discussion.

Often live stock provides employment for members of the family whose time may, in some cases, not be worth much. Chickens, turkeys, swine and sheep are often cared for by children. Dairy cows are often cared for and milked by the women and children. Calves may be taken care of and raised on skim milk by the children. All of this otherwise unproductive labor is turned into good account and is a factor analogous in the production of products cheaply, to the waste feeds used in producing fine products.

6. *Animals enable the farmer to make more constant use of his capital.* — The farm labor is distributed better in animal husbandry farming than in producing a single crop or several crops. This was suggested in the preceding paragraph. The capital secured from the sale of a surplus crop may be used in purchasing young growing animals. Barns, sheds, teams, tools and implements are in more constant use where animal hubandry is practiced. The land is also used more constantly. The lands that are rough and hilly, the cornstalk fields and other soils that are used in producing crops, may become good pasture lands after the crops are harvested. This prolongs the yearly length of usefulness of the land.

The cotton producers of the South, the wheat producers of the Dakotas, the oat and corn producers are without employment except for a few months of the year. Their income also is received within a short time. Some of these farmers expend all their funds when secured, and hence are rather unfortunate the rest of the year. Animal husbandry makes more constant use of this

as well as of farm buildings, implements, etc. — a decided advantage for animal husbandry.

7. *Animals produce work, food and clothing.*—All the domestic animals work. Horses pull the plow and the wagon. Beef cattle transform the grasses and other feeds into beef. They enable the farmer to manage a large farm. Dairy cattle likewise work over a large quantity of raw feeds, and manufacture from them a fine edible product. Swine and sheep also are manufacturers of fine products. Turkeys and chickens destroy many insects and hence save labor. There are various other ways in which the farm animals work.

Not only do animals work, but they produce food. Milk and its products, meat and eggs are among the best of human foods. The casein of milk, the albumen of eggs and the myosin of meat are excellent nitrogenous foods. These fine nitrogenous foods supplement the carbonaceous foods coming from the cereal kingdom, and help to balance the ration. In 1890 the average amount of meat consumed per person in the United States was 450 pounds; in 1912 it was 180 pounds. For growing children and for the hard-working person, milk, meat, and eggs are very essential.

Leather and wool are indispensable articles in the making of clothing.

8. *Animals help in making nations great.* — The greatest nations of the world have been producers and consumers of meat and animal products. The Hebrews, the Romans and the Teutonic races have contributed some of the best elements of the world's civilization. The Christian religion comes from the Hebrews; many present day laws come from the Romans; and the Democratic type of government comes from the Teutonic peoples. The Hebrews, the Romans and Teutonic peoples were producers of animals, and used animal products.

We do not need to indicate at length the lack of progress among the nations of people that live exclusively on either a meat or vegetable diet. The Chinese eat vegetable products, — rice;

the Esquimos eat animal fats. Neither has contributed in a remarkable way to the world's progress.

Even the most progressive states of the United States, as shown by their roads, schools, farm implements, churches and public buildings, are greater producers of animals than are those states more backward along these lines. On this point in connection with dairying, Professor Eckles states in his book, *Dairy Cattle and Milk Production*, "If a list were prepared of our own states, selecting those where the average soil fertility is best conserved and the most intelligence found among the people, it would be a list of the leading dairy states." The American people are consumers of greater quantities of animals product per capita than are the peoples of any other nation. And where may a superior people, both physically and mentally, be found? A permanent agriculture is conducive to the development of men and women, both physically and mentally.

Summary. — Animal husbandry has the following advantages: Animals help in maintaining the fertility of the soil, in utilizing cheap feeds and using waste lands, in promoting and establishing good crop rotations, in acting in the capacity of manufacturers, in helping to distribute labor, in enabling the farmer to make more constant use of his capital, in providing work and food, and in helping to make nations great. All of these are essential to a prosperous and happy people. Systematic agriculture, permanent agriculture, and productive agriculture, — an agriculture that is stable and abiding is promoted by animal husbandry. Generally speaking, no one can make a serious mistake by keeping and feeding the right kind of young, growing animals.

QUESTIONS

1. What are the advantages of animal husbandry?

2. Which of the advantages named make for lower cost of animal production?

3. Name some peoples or nations that have been consumers of vegetables only; of meats only. Compare their greatness with peoples who have been consumers of both products.

4. Name a good system of crop rotation. Why do you consider it a good system?

5. Name ten feeds that would be practically worthless, if they could not be consumed by farm animals.

PROBLEMS

1. Briefly report on the history of the leading nations, as to their contribution to the world, and briefly discuss the foods they consumed.

2. Report on the topic "The Relation of the Work of the Horse to Economic Crop Production."

REFERENCES

Henry and Morrison, Feeds and Feeding. — Introduction.
Bailey's Cyclopedia, Vol. III.
Eckles, Dairy Cattle and Milk Production.

CHAPTER XIV

IMPROVEMENT OF FARM ANIMALS

Recent improvement of farm animals. — Although live stock have been wonderfully improved in the last 20 or 30 years there is still plenty of room for improvement. This is true of horses, beef cattle, dairy cattle, swine, sheep and poultry. All types of animals are more efficient to-day in form and function than they have ever been. Thomas Hunt in Bailey's Cyclopedia is responsible for the following statement: "In 1850 sheep produced on an

Courtesy Ginn and Co.

FIG. 70. — A good producing cow produces enough milk to nourish a dozen to fifteen calves. The native cattle gave about enough milk to nourish one small calf.

average 2.4 pounds of wool; in 1900 they produced 6.9 pounds per fleece. The increase per cow in the production of milk and more particularly of butter fat in the same period would be no less striking if statistics existed to show it." The average amount of milk produced by the dairy cows of the United States in 1909 was 3100 pounds.[1] It is slowly increasing.

[1] 1910 Census Report.

The ordinary farm horse in America to-day is probably 25 per cent more efficient than horses were in 1850. At that time the average team weighed about a ton. About 1900 the best teams weighed about $1\frac{1}{2}$ tons, and to-day the best teams weigh about two tons.

Grading up live stock. — Grading up is the practice of mating unimproved females with pure bred males of improved breeds. The offspring are mated again with males of the same breed, and this is continued for any number of generations. In practice the disappearance of the characteristics of the unimproved animals is about as follows, making, of course, some allowance for prepotency and variations. The predominance of the characteristics of the good pure bred sire is also shown in the table.

GRADING UP UNIMPROVED ANIMALS BY THE CONTINUOUS USE OF PURE BRED SIRES

GENERATIONS	SIRES PER CENT PURITY	DAMS PER CENT PURITY	NUMBER OF ANCESTORS	PER CENT PURITY		INFLUENCE OF EACH GENERATION Per Cent
1	100	0	2	50	$\frac{1}{2}$	50%
2	100	50	4	75	$\frac{3}{4}$	25%
3	100	75	8	87.5	$\frac{7}{8}$	12.5%
4	100	87.5	16	93.75	$\frac{15}{16}$	6.25%
5	100	93.75	32	96.87	$\frac{31}{32}$	3.125%
6	100	96.87	64	98.44	$\frac{63}{64}$	1.5625%

In grading up the first offspring has 50 per cent purity of blood, the second 75 per cent, the third 87.5 per cent and so on. The characteristics of the pure bred animal are more nearly approached from generation to generation, and as the percentage of blood of the scrub vanishes, the certainty of the transmission of the characteristics of the pure bred animal is assured. It is likely that the animals represented in the picture, page 194, will transmit the characters and qualities they themselves possess.

Scrubs, grades and pure breds. — A *scrub* animal is one that has in its veins little or no blood of any definite breed. The native

animals were scrubs because their qualities came from various sources.

A grade animal is one that has 50 per cent or more blood of some definite breed of animals in its veins. We associate the term grade with a breed name, as Grade Hereford, or Grade Percheron, etc.

A high grade animal is one that has in its veins a large proportion, 75 per cent or more, of blood of a definite breed. It is usually the product of a grade dam and pure bred sire of the same breed.

Pure bred animals are those animals whose ancestors from

Courtesy Harris Bros.

FIG. 71. — A Hereford family, showing uniformity, improvement and breeding.

both sides have been pure bred for many generations. The term "thoroughbred," referring to the English running horse, is often misused for the term *pure bred*.

What are the advantages of good high grade and good pure bred animals? (1) They will transmit their qualities or characters with great uniformity. They breed true to the characteristics of the breed. We know that we will get Percheron characteristics from Percheron parents, Leghorn chickens from Leghorn parents. Of course, the parents must be alike, not only in appearance, but in other qualities. (2) Pure bred, or high grade animals with the same features in color, conformation and quality sell for more money than animals of mixed breeding. Everybody

likes a matched team. We all prefer a uniform lot of cattle, sheep, horses, mules, poultry, or any other product. They sell for more money. (3) Pure bred animals are adapted to definite purposes, — the Holstein cow is valued for quantity of milk; the Jersey for butter fat; the Hereford cattle are good rustlers, adapted to the Western ranges; the Galloways are adapted to the severe climate conditions; the draft breeds of horses to draft work. An indefinite

FIG. 72. — Hampshire sheep possessing uniform feature throughout, not only in color but also in other characteristics. What will the next generation be like?

number of illustrations might be given to show that different pure bred animals are adapted to definite purposes. (4) Better results are secured per unit of feed from pure bred animals than from scrubs. Many dairy cows annually produce over 5000 pounds of milk, many produce more than 10,000, and some more than 20,000. A hundred pounds of feed fed to pure bred animals gives better and larger returns than when fed to Texas Longhorn cattle. (5) Pure bred animals are more attractive. They look

better, do better and sell better. (6) Cost of keep is no more for pure breds than for scrubs, and in some cases is less. (7) More pride is taken in pure bred stock than in scrubs. This is an important factor in getting the best results from any kind of work, and especially from live stock production.

The lines of improvement of animals. — We improve animals for the following purposes:

1. To increase their size.
2. To improve their form.
3. To improve milk producing ability.
4. To improve the speed of the horse.
5. To improve meat producing ability.
6. To increase their prolificacy.
7. To increase and improve wool production.
8. To increase egg yield.
9. To improve color.

It is the aim of this chapter to indicate how the improvement and value of live stock centers about the above essential points which underlie, in a large measure, the successful production of farm animals, and how a community may improve its live stock through community coöperation.

1. *Increase of size* is an important point. The various breeds of horses came from the same ancestors. The prices of draft horses and mules are largely governed by weight and size. A horse of good quality and character weighing 1500 pounds will sell for $200, when a horse of the same conformation weighing 2000 pounds will sell for $300. Size and weight are two important qualities in mules, and their price per pound increases a great deal with increase in weight. A mule weighing 1000 pounds may sell for 12 cents per pound, when one weighing 1500 pounds will sell for 18 cents per pound. It would pay our farmers to increase the size of their horses and mules for they would bring more money per pound.

The following table taken from Craig's book entitled *Judging*

Live Stock shows the relation of weight to price per pound. The table is based upon a year's data secured from the sales of horses on the Chicago markets.

WEIGHT AND SIZE INFLUENCING PRICES OF HORSES

AVERAGE WEIGHT	AVERAGE PRICE	CENTS PER LB.
1400	$155.87	$0.111
1450	159.15	0.109
1500	169.15	0.112
1550	176.56	0.114
1600	176.62	0.110
1650	208.64	0.126
1700	212.89	0.125
1750	236.14	0.126
1800	258.33	0.135

It will be noted that horses weighing 1800 pounds brought over $100 more than horses weighing 1400 pounds. The extra 400 pounds brought $100, or 25 cents a pound. It indicates that a heavy horse has a differential advantage on the market.

The following grade stallion is represented here, with an apology to all good horses and lovers of good horses. This horse transmits neither size nor quality. He is a scrub and should be treated as such.

2. *Animals may be improved in form.* — Each domestic animal has a far more pleasing and a far more serviceable form than had the wild animal from which he came. The picture of a wild boar and his daughter, a half pure bred Berkshire, represents the improvement in form wrought among animals. See page 308.

Horses, cattle, sheep, fowls are changed in form according to the wishes of the breeder. A breeder once said, "Let any one draw a picture of the most perfect animal, and in several generations he could secure an animal as perfect as the picture." This is being done constantly. Animals are changed in form because they will fulfill the demands placed upon them with greater effi-

ciency. Form is an important consideration in the improvement of any type or breed of animal.

3. *Greater milk-producing ability is a quality sought in dairy cattle.* — The following data are taken from Eckles' book *Dairy Cattle and Milk Production.* He says: "The remarkable variation in the transmission of dairy qualities by different bulls is

Courtesy Wisconsin Station.

FIG. 73. — An old Wisconsin grade trotting-bred stallion; used for service as occasion offers and frequently "traded off" to a new owner.

shown by the results from the University of Missouri Jersey herd. The following two tables show the variations in transmitting milking ability of dams and daughters, and the relation of the sire to the function of milk production of his daughters. Missouri Rioter had four daughters that had a total of 26 lactation periods, and their dams had 23 lactation periods.

The daughters produced 999 pounds of milk less and 18 pounds of butter fat less on an average in each of 24 lactation periods than their dams. This clearly indicates that Missouri Rioter did not transmit milk producing ability, the quality that was wanted.

	Dams	Daughters
Average milk yield	5380	4381
Average per cent fat	4.35	4.93
Average yield of fat	234	216

Missouri Rioter 3d, son of Missouri Rioter, left a better record. His mother was the best cow in the herd up to that time. Missouri Rioter 3d had three daughters with records of 15 lactation periods, and 14 lactation periods of their dams are on record. The transmission of milk producing qualities of Missouri Rioter 3d is shown in the following table:

	Dams	Daughters
Average yield milk pounds . .	4775	8005
Average per cent fat	4.97	4.80
Average yield of fat	238	384

The daughters produced on the average 3230 pounds of milk and 146 pounds of butter fat per year more than their dams. These data indicate that Missouri Rioter 3d did transmit the qualities that were desired.

One of the most important problems in dairying is the selection of sires that will transmit milk producing ability. No other test except the performance record of the daughters is a guarantee that a sire possesses this important quality. The records of the dams and daughters must both be kept to determine whether or not improvement is really being made.

4. *To increase speed* has been one aim in the improvement of the horse. Any horse may be registered as a Standard Bred

Trotter, provided he can trot a mile in two minutes and thirty seconds; and any horse may be registered as a Standard Bred Pacer if he can pace a mile in two minutes and twenty-five seconds. Although the first trotters did not exceed a three-minute rate, and the first pacers did not go much faster, yet at the present time we have some horses that can trot or pace a mile in less than two minutes. This example clearly shows what power man has over changing the speed of the horse, and correlating form and function.

5. *Meat producing ability.* — Much has been done in changing the meat producing ability of animals. The use of the pure bred sire in grading up live stock has played an important rôle in keeping up the meat supply even if the number of animals has decreased. The improvement thus wrought also maintained the price and the total amount of money received. The value of a good sire is illustrated by an experiment carried on at the Missouri Station with the use of a pure bred ram and a scrub ram.[1]

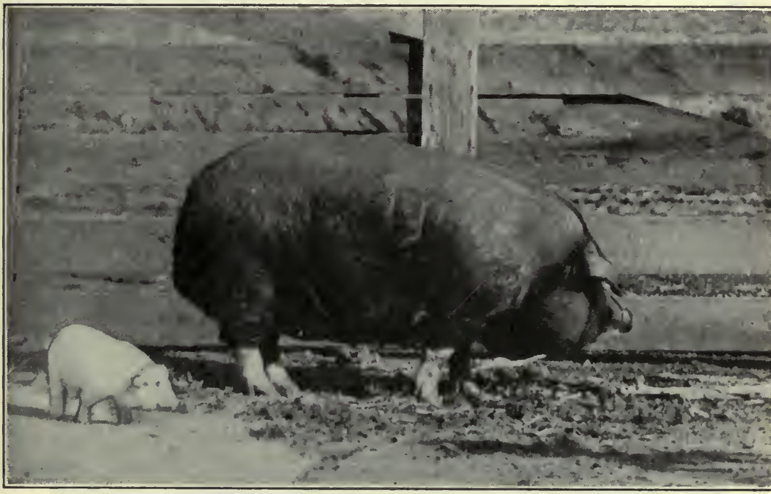
Seventeen lambs from a pure bred sire and Western ewes weighed on an average 63 pounds when three months old and sold for $7.35 per hundredweight; while 17 lambs sired by a scrub ram weighed 56 pounds when *four months* old and sold for $4.50 per hundredweight. Besides this the good lambs required less feed to produce one hundred pounds of gain.

There are a great many hogs, sheep, fowls and beef cattle that can be improved in their meat producing ability by the use of a well-conformed, good, pure bred sire. Here is one of the most fertile fields for making money. Good breeding pays. Poor breeding must be overcome by an additional expenditure for feed.

6. *To increase prolificacy.* — Just as some plants are more prolific than others, so are some animals more prolific than others. It is fortunate that barren plants and animals are the last link of their kind. And practically speaking, animals that will reproduce reluctantly are soon abandoned, for it does not pay to keep them. Thus, at one time the Poland China breed of hogs was

[1] Missouri Station, Circular No. 65.

pampered, so that the number of pigs to the litter became so small that either the breed had to die a natural death, or be changed. The fine boned small type of Poland China hog gave way, to a large extent, to the large boned Poland China hog of to-day.



Courtesy Sanders Pub. Co.

FIG. 74. — A sow that has a good form but lacks prolificacy means expensive pork production when there is only one pig in the litter.

These large Poland China hogs are prolific; had they not been so, other breeds would have replaced them. The above picture and one on the following page indicate differences in animals that determine whether they are to be reckoned as assets or liabilities in the farm accounts.

7. *Breed for increase of wool production.* — Sheep, horses, cattle, and other live stock must be prolific, or become extinct, because animals that reproduce slowly are uneconomic, and the farmer must for financial reasons abandon them. Wild sheep produce very little wool, and it is coarse and hairlike. The native wild sheep sheared less than two pounds of wool yearly. To-day we have records of sheep shearing from 20 to 30 pounds in a year's

time. Laramie, a Rambouillet ram, owned by the Agricultural College of Stillwater, Oklahoma, was sheared at the end of fifteen months and his fleece weighed 46 pounds. However, there are too many fleeces weighing only four to six pounds. Here is a chance of crossing the ewes with a good wool producing ram, such as Laramie was, and thus increasing wool production to an appreciable amount. Never before has the outlook for good remuneration for wool production been better than it is at the present time. That the average farmer could make a fair profit by keeping on

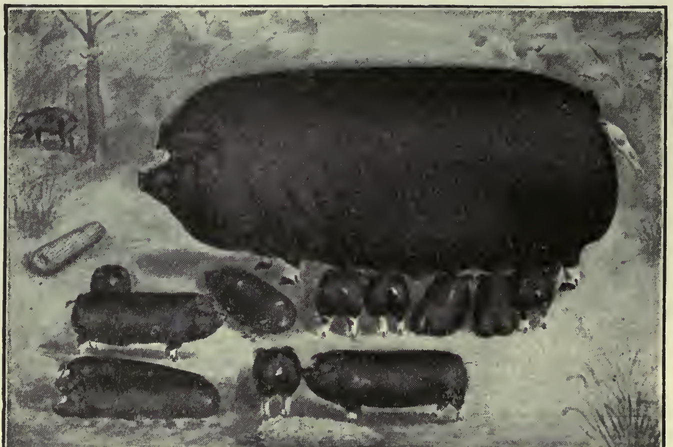


FIG. 75. — A large litter reduces the cost of pork production.

his farm from 25 to 30 sheep is the opinion of the best authorities on sheep raising. That wool will remain a staple article for clothing remains unchallenged.

8. *To increase egg production.* — We have long known the difference in the conformation between the draft horse and the light horse; the beef cow and the dairy cow; the lard hog and the bacon hog; the mutton sheep and the wool sheep; and the bull dog and the bird dog. But we have not studied very closely the hen that will lay and the one that will not lay. That all the

above types of animals have a conformation in harmony with their function is also well known; but that there is in poultry a relation between form and function has been largely ignored. It is time that we study more closely form and function in poultry to see if any correlation exists between the two. This has been worked out by Professor Hogan, and he has explained it in his book entitled *The Call of the Hen*. The Hogan test, which enables us to tell the layer from the non-layer, will be discussed in the chapter on Poultry. Suffice it to say that the average production of eggs in the United States is estimated to be about 64 eggs per hen. There are, however, hens that will lay 150 to 200 eggs per year. At the Sixth National Egg Laying Contest held at Mountain Grove, Missouri, each of 81 hens produced 200 eggs or more during the year of the contest. The average number of eggs produced by the 290 hens in the contest was 175.2. The good producers have a conformation and temperament favorable to greater egg production.

9. *To improve the color of animals.* — Color continues to engender more pride than any other quality in live stock. The white markings on Hereford cattle constitute a distinct feature of the breed. The Barred Rocks must be regularly barred into the skin, and each feather must have a black tip. To maintain this barring, according to the American Standard of Perfection has caused more trouble and study than any other factor in the breeding of Barred Rocks. Berkshire hogs must have six white tips, — and they don't secure prizes when they have black feet. Each breed of sheep has specific color markings. Each breed of horses has a most desirable color. A black mule having a mealy muzzle looks best. To improve and maintain definite color and color markings has provoked as much thought as any other point in the improvement of live stock.

Improvement of animals through community action. — Although we frequently find individuals who have sufficient means to finance the improvements needed in a community, more often the best, most substantial improvements are brought about through the

concerted, coöperative action of the entire community. All public buildings, churches, schools, courthouses, and other public buildings are thus built. County, state, and interstate roads are built by the entire social group.

While the improvement of live stock has been due mostly to individual and private effort, there are many communities that could profitably resort to community breeding. One breed of animals supported by a large community has many advantages: (1) The community becomes known as a breeder of Percheron horses, Holstein cattle, or whatever it may be; hence purchasers come in from a distance because they know they will have a large number of animals from which to select; (2) The maintenance and service of an extraordinary sire is reduced in cost; (3) The community can become acquainted with one breed of animals; comparisons can be made regarding feed, management, and results of individuals of the breed, for the neighbors' animals help in setting up standards; this gives a man a true basis for comparison; (4) The good surplus males can be disposed of to advantage in a community where there is a common breed; large numbers give the best chance for selection and improvement.

Dean Mumford in his book entitled *The Breeding of Animals* says: " In some localities community interests in the improvement of live stock has taken the form of coöperation among three or four small breeders in the purchase of a valuable bull. In the United States many associations have been formed among farmers for the purchase of a stallion.

" Even in the absence of conscious coöperation for improvement, if a large number of farmers in a given neighborhood are like minded in the selection of breeds and all produce the same breed, each particular animal will actually be more valuable because prospective buyers will be attracted by the opportunity for selection where large numbers are available."

Summary. — Dairy cattle are probably five to ten times as efficient as the original native cattle were; our beef cattle are from two to three times as capable in putting on beef as were the

native steers; our horses in the race and in labor are greatly improved; our sheep are from 200 to 400 per cent more efficient wool producers than were the wild sheep; and our chickens are from 200 to 600 per cent better egg producers than the original Gallus Bankiva. These are the lines along which improvement still centers. Scrubs are disappearing, and grades and pure breds are taking their place. Grading up is still one of the great opportunities in making improvement, thus building up the common herd so that it continues to be profitable.

Community coöperation is the key to success for the small breeder, for a community can do many things that the average individual cannot undertake. There is an advantage in having large numbers. Dean Mumford, the author's former teacher, says, " A noted breeder of dogs who was asked to give the secret of his success replied, 'I breed many and hang many.' " A community can do this and still continue to exist, while an individual cannot stand more than one or two hangings. Community coöperative associations for the improvement of live stock are certain to play a large part in the further improvement of our farm animals.

QUESTIONS

1. In what different respects have the different farm animals been improved?
2. Define scrub, cross bred, grade, high grade, and pure bred.
3. What are the advantages of pure bred animals over scrubs?
4. What are the points you would emphasize in the improvement of horses? Dairy cattle? Poultry?
5. Discuss the topic, "The Relation of the Improvement of Animals to Economic Production."

PROBLEMS

1. Name the breeders of pure bred stock of your county. (Information may possibly be had from the County Agricultural Agent.)
2. Report from various sources at your disposal on the sales and sale prices of pure bred stock.

REFERENCES

Mumford, The Breeding of Animals.
Davenport, Principles of Breeding.

CHAPTER XV

FEEDING FARM ANIMALS

Importance of scientific feeding. — The economical feeding of farm animals is one of the large factors in making the farm productive and profitable. How to get the most out of the feed produced on the farm is an important question confronting every feeder. To do this one must know something about the composition of the feed and the product produced, and the factors that affect the value of a feed. These we shall discuss, for many farmers must be successful feeders if they are to make their farm operations successful.

1. *What feeds are for.* — Feeds are fed for the purpose of producing work, meat, milk, wool and eggs. All parts of the body must be supported, bone and flesh, horn and hoof, muscle and tendon, hair and wool. Animals use feeds for maintenance, for growth and for reproduction.

In order that we may feed fairly well we should know something of the composition of the thing produced. For that reason we give the chemical composition of some of the things produced.

Approximate Percentage Composition of Some Animal Products

	Dry Matter	Protein	Carbo-hydrates	Fats	Ash
Beef steer	47.0	13.5	0.0	34.0	3.60
Fat pig	51.0	12.0	0.0	40.0	2.25
Fat lamb	55.2	12.3	0.0	28.5	2.94
Chicken	55.8	1.6	0.0	17.0	3.8
Milk	13.6	3.5	5.0	4.4	0.7
Eggs (edible part)	26.0	14.9	0.0	10.5	0.8
Human body	42.0	18.0	1.0	17.0	5.5

A beef steer contains 53 per cent water, 47 per cent dry matter, 13.5 per cent protein, no carbohydrates, 3.4 per cent fats, and 3.6 per cent ash. The elements making up the above compounds must be provided in the feed, before that product can be made. From the above table it may be seen that animal bodies are composed of approximately 50 per cent water. This is an important fact to remember in feeding.

2. *Composition of plants and feeds.* — Green blue-grass is more nearly a perfect feed for all classes of live stock than any other one feed. The farmer and dairyman often wonder at the good results secured from blue-grass alone. They wonder by what alchemy blue-grass produces so well. The producing ability of blue-grass must be due to its composition, which is as follows:

Percentage Composition of Blue Grass

	Dry Matter	Protein	Carbohydrates	Fats	Ash
Blue-grass	31.6	2.8	23.5	1.2	2.8
Beef steer (for comparison)	47.0	13.5	0.0	34.0	3.8

Thus it will be seen that blue-grass and a beef steer are similar to quite an extent in chemical composition.

The table on the next page gives, not the chemical composition, but the *digestible composition* of a number of common feeds. The digestible composition of a feed is that portion which is digestible. It is generally about three-fourths of the total chemical composition. The comparison of the digestible composition of blue-grass and the other plants with the chemical composition shows that this is approximately true.

It may be noted from the table that all feeds given are more or less alike, and it will be time well spent to study and compare the different feeds closely, and also to learn approximately their nutritive ratio.

PERCENTAGE DIGESTIBLE COMPOSITION OF SOME OF THE COMMON FEEDS, AND NUTRITIVE RATIO

	TOTAL DRY MATTER	POUNDS OF DIGESTIBLE NUTRIENTS IN 100 LB.				
		Crude Protein	Carbohydrates	Fat	Total	Nutritive Ratio is as 1 is to
Corn products:						
Dent corn . .	89.5	7.5	67.8	4.6	85.7	10.4
Gluten feed .	91.2	15.1	57.8	4.8	83.7	4.5
Germ oil meal	92.2	10.0	50.3	10.0	82.8	7.3
Wheat products:						
Wheat . . .	89.8	9.2	67.5	1.5	80.1	7.7
Bran . . .	89.9	12.5	41.6	3.0	60.9	3.9
Middlings . .	89.6	13.4	46.2	4.3	69.3	4.2
Oats:						
Oats . . .	90.8	9.7	52.1	3.8	70.4	6.3
Oat straw . .	88.5	1.0	42.6	0.9	45.6	44.6
Hays:						
Timothy . .	88.4	3.0	42.8	1.2	48.5	15.2
Alfalfa . . .	91.4	10.6	39.0	0.9	51.6	3.9
Red clover .	87.1	7.6	39.3	1.8	50.9	5.7
Cowpea . .	90.3	13.1	33.7	1.0	49.0	2.7
Soy bean . .	91.4	11.7	39.2	1.2	53.6	3.6
Grasses:						
Blue-grass . .	31.6	2.3	14.8	0.6	18.5	7.0
White clover .	21.8	3.1	9.6	0.5	13.8	3.5
Red top . .	39.3	1.9	20.0	0.6	23.3	11.3
Meat products:						
Tankage . .	92.5	48.1	0.0	13.7	78.9	0.6
Meat scraps .	94.0	37.0	0.0	11.0	61.8	0.7
Cow's milk . .	13.6	3.3	4.9	4.3	10 2	4.4
Skim milk, gravity . .	9.6	3.1	4.6	0.9	9.7	2.1
Buttermilk . .	9.4	3.4	4.9	0.1	8.4	1.5
Corn silage . .	26.3	1.1	15.0	0.7	17.7	15.1
Cottonseed meal, good . . .	92.1	31.6	25.6	7.8	74.8	1.4

Table from Henry and Morrison, *Feeds and Feeding*.

Comparison of composition of plant and animal bodies.— The constituents of animal and plant bodies are very similar. First both contain water and dry matter, both contain protein, fats

and ash. Animal bodies do not contain carbohydrates, which comprise starches and sugars. The carbohydrates of plants are converted into the fats of the animal bodies. It will be well at this point to study and compare closely the water, protein, carbohydrate and fat content of animal bodies and plants from the two tables preceding in this chapter. The function of the different constituents in feedstuffs will be discussed in a later paragraph.

The ash ingredients in plants and animals are also somewhat alike, as is shown by the following table.

POUNDS OF ASH INGREDIENTS IN 1000 POUNDS PLANTS AND ANIMALS

	PHOSPHORIC ACID	POTASH	LIME	MAGNESIA
Plant Products				
Dent corn	6.9	4.0	0.2	1.8
Wheat	8.6	5.3	0.6	2.2
Oats	8.1	5.6	1.4	2.0
Wheat bran . . .	29.5	16.2	0.9	7.3
Alfalfa hay	5.4	22.3	19.5	5.9
Cotton seed meal . .	26.7	18.1	3.6	8.6
Red clover hay . .	3.9	16.3	16.0	4.5
Animal Products				
Fat calf	15.35	2.06	16.46	0.79
Fat pig	6.54	1.38	6.36	0.32
Fat lamb	11.26	1.66	12.81	0.52
Milk	2.00	1.70	1.70	0.20
Wool	0.70	56.20	1.80	0.40

Table adapted from Henry and Morrison, *Feeds and Feeding.*

A careful study of the above table will indicate that the ash ingredients in plants and animals are very similar. This is a fine thing, for although corn and the cereals in general contain very little lime the legumes contain much. It does not require many varieties of feeds to balance the ration as far as the mineral matter

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is concerned. These tables, although a little tedious, deserve close study, because they sustain an important relation to successful feeding.

Function of the different ingredients in feedstuffs. — By way of introduction we may say that the components of the plant have the function of making up the same components in the animal body, with the exception of carbohydrates, which may be made into fats. They also have some other functions. These cannot all be discussed in this brief treatment.

Water, which is composed of hydrogen and oxygen and covers three-fourths of the globe, makes up about that same proportion of green plants, and constitutes about one-half of animal bodies. Its first function is to make up its proportional part of the tissues. It helps in digestion and aids in the elimination of waste products through excretions. It also helps to control the temperature of the body through perspiration.

Carbohydrates, composed of carbon, hydrogen, and oxygen, and comprising all sugars and starches, make up a large proportion of feedstuffs. They have two functions to perform: (1) They furnish heat to the body. Carbon, hydrogen, and oxygen are excellent heat producers. One of the big problems in feeding is to keep the animals warm. This may be accomplished by feeding carbohydrates. This is the type of feed to provide in greater abundance during cold weather. Corn in the feeding world corresponds to coal in the fuel world, for it is corn that keeps the animal kingdom warm. (2) The second function of the carbohydrates is to make fat. Fats have the same elements that the starches and sugars have and are often defined as concentrated carbohydrates. The carbohydrates are excellent fatteners.

The fats have the same function that the carbohydrates have, namely, energy and fats. Fats furnish $2\frac{1}{4}$ times as much heat as do carbohydrates. Butter yields 3600 calories of heat per pound, while starch yields 1565 calories. A pound of tomatoes has 80 calories of heat. How to keep cool is partially explained in the above few lines.

The proteins are composed of carbon, hydrogen, oxygen and *nitrogen*, which is the characteristic element, and build bone, muscle, tendon, horn, hoof, skin, hair and wool. There are five sources of five kinds of proteins: namely, eggs, which contain albumen; meat, myosin; milk, casein; cereals, gluten; legumes, legumin. *Nitrogen* is the distinguishing element in each of these proteins. The proteins are the highest priced foods and feeds we have. They are absolutely necessary for growth, vigor, life and energy. Any animal doing a lot of physical work must be sustained by an abundance of energy producing feeds, or proteins. The figure on page 213 illustrates the importance of protein in the ration.

The ash elements, comprising the oxides of phosphorus, potassium, calcium, magnesium, iron, sulphur, sodium, chlorine and silicon, help in making bone and tissue. With the exception of the silicon, the ash elements, each and every one of them, are as essential to life as air and water. They are not considered in balancing a ration ordinarily, but that the ash elements are just as essential to a balanced ration as the proteins, carbohydrates and fats remains unquestioned.

Henry and Morrison say in *Feeds and Feeding:* "In forming rations the calcium and phosphorus content of the feeds should be considered. Straw, chaff, the various root crops, the *cereals and their by-products*, such as bran and middlings, are low in *calcium*. On the other hand the legumes, as clover, alfalfa, and the leguminous seeds, such as beans and peas, are high in *calcium*. The first named feeds are high in *phosphorus*, and the legumes are low in *phosphorus*. Calcium and phosphorus must be well considered in balancing the ration."

Hart, McCullum and Fuller, at the Wisconsin Station,[1] carried on an experiment with five lots of pigs. In each lot the pigs averaged 47.0 pounds each at the beginning of the experiment. In each case different kinds of feeds were fed to determine something regarding the mineral requirements for pigs. The table is largely self-explanatory.

[1] Wisconsin Research Bulletin No. 1

THE RESULTS AT END OF 120 DAYS FEEDING FOLLOWS:

	Lot 1. No Phosphorus Added	Lot 2, Calcium Phosphate Added	Lot 3, Bone Ash Added	Lot 4, Ground Rock Phosphate Added	Lot 5. Unwashed Wheat Bran
Average amount of phosphorus fed daily, grams	1.12	5.29	5.45	5.20	5.28
Weight of pigs at slaughter, pounds	77.0	87.	85.	82.	87.
Average gain per pig, pounds	32.	42.	35.	43.	58.
Weight of skeleton, grams	870.	950.	950.	1495.	850.
Breaking strength of thigh bone per square millimeter, pounds .	0.87	1.70	1.77	1.65	1.86
Diameter of thigh bones, millimeter	16.	16.	15.5	20.0	17.
Specific gravity of thigh bone	0.98	1.15	1.12	1.19	1.14
Ash in thigh bone, per cent	33.	46.	53.	57.	54.

The pigs in all lots were fed a fair allowance but the pigs in Lot 1 gained an average of only 32 pounds each; while the average weight of the pigs in the other four lots was 44.5 pounds. The breaking strength of the thigh bones of Lot 1 was about half as much as it was for the other pigs. The ash and specific gravity of the bones of pigs in Lot 1 were also much less. What do these results indicate? They indicate that we must include the ash elements in the consideration of the requirements of animals.

Food requirements of animals. — In addition to the above requirements of animals discussed in general terms let us study the requirements more in detail. Although we have other feeding standards for stock, such as Armby's Standard, a standard based upon the heat energy of feeds, and the Kellner Standard, based on the starch value of a feed, the Wolff-Lehmann Standard is the easiest and best understood by our farmers and is probably the best standard for general purposes that has been proposed. For this reason the feed requirements according to this standard are

given. For a discussion of other standards refer to Henry and Morrison's book on *Feeds and Feeding*.

Wolff and Lehmann found that animals that were idle did not require any feed for production, but needed only a ration for maintenance. They learned that growing animals needed a growing ration; a fattening animal, a fattening ration; a milch cow, a ration that would maintain her body and also produce milk; and a wool sheep, a wool producing ration.

After long experimentation they published the following requirements, which are excellent, and are known as the Wolff-Lehmann Feeding Standards.

WOLFF-LEHMANN FEEDING STANDARDS — PER 1000 POUNDS LIVE WEIGHT

	Dry Matter	Digestible Nutrients			
		Crude Protein, Lb.	Carbohydrates, Lb.	Fat, Lb.	Nutritive Ratio 1 is to
Horses:					
Light work	20	1.5	9.5	0.4	7.0
Medium work	24	2.0	11.0	0.6	6.2
Heavy work	26	2.5	13.3	0.8	6.0
Fattening cattle:					
First period	30	2.5	15.0	0.5	6.5
Second period	30	3.0	14.5	0.7	5.4
Third period	26	2.7	15.0	0.7	6.2
Sheep:					
Coarse wool	20	1.2	10.5	0.2	9.1
Fine wool	23	1.5	12.0	0.3	8.5
Milch cows:					
Giving 11.0 lb. milk	25	1.6	10.0	0.3	6.7
Giving 22.0 lb. milk	29	2.5	13.0	0.5	5.7
Swine growing:					
2–3 mo. old weighing about 50 lb.	44	7.6	28.0	1.0	4.0
Fattening swine	32	4.0	24.0	0.5	6.3

From the table we may see the requirements of animals in accordance with the purpose for which they are fed. That is, a horse doing light work has slightly different feed requirements from a horse doing heavy work. The Wolff-Lehmann requirements

[1] Taken from Henry and Morrison, *Feeds and Feeding*.

deserve close study. After a discussion of the nutritive ratio of feeds we shall discuss how to balance a ration in accordance with the Wolff-Lehmann requirements.

The meaning of nutritive ratio (N. R. abbreviated). — The nutritive ratio of a feed is the relation of the digestible crude protein to the digestible carbohydrates, plus the digestible fats multiplied by two and one-fourth. It is the relation of the physical energy producing portion of the feed (protein) to the heat producing portion (carbohydrates and the fats). The N. R. is the relation of the nitrogenous to the carbonaceous portion of a feed. A feed that has a narrow N. R. or much nitrogen is called a nitrogenous feed; and a ration containing a lot of carbohydrates is called a carbonaceous feed or ration.

The N. R. of any feed is found by multiplying the digestible fat by two and one-fourth, adding this to the digestible carbohydrates, and dividing the sum by the digestible crude protein. The equation of the N. R. is written as follows, and the nutritive ratio of dent corn is thus found:

$$\text{N. R.} = \frac{\overset{\text{Dig. fat}}{4.6} \times \overset{\text{Heat energy}}{2.25} + \overset{\text{Dig. carbo.}}{67.8}}{\underset{\text{Digestible protein}}{7.5}} = 10.4$$

that is, the N. R. of corn is as 1 : 10.4. The N. R. of any feed may be found in like manner.

What is the meaning of narrow nutritive ratio and wide nutritive ratio? By the term *narrow* N. R. we mean that the relative amount of protein to the carbohydrates and fats is large. Thus in the table, page 208, we notice that the N. R. of cotton-seed meal has a high proportion of protein to the carbohydrates and fats, and has a narrow N. R. A *wide* N. R. is just the reverse. It indicates that a feed is carbonaceous, containing a high proportion of carbohydrates and fats in relation to the protein. Find the N. R. for corn silage and oat straw. They are somewhat wide.

From the study of the Wolff-Lehmann requirements we learned that the N. R. requirements for animals for various purposes

ranged from 1 : 4.0 in the case of growing pigs, to 1 : 9.1 in the case of coarse wool production. From the standpoint of purpose, therefore, we may say that a N. R. less than 1 : 4 is narrow; and wide, if the N. R. is more than 1 : 10.

Henry and Morrison state, "Except in the case of very young animals, it is, however, probably not advisable to feed rations having a nutritive ratio narrower than 1 : 4 or 1 : 4.5."

Physiologists tell us that the human body requires from eight to ten times as much carbonaceous foods as nitrogenous foods, or foods in which the N. R. is about 1 : 8. This requirement corresponds to the requirements of lower animals.

The N. R. and a balanced ration should not be confused. The N. R. of oat straw is as 1 : 44.6, and of cotton-seed meal 1 : 1.4; neither is a balanced ration for anything.

Balanced ration. — A balanced ration is the feed or feeds providing the proper proportion of the digestible nutrients, — crude protein, fats and carbohydrates, — so that the animal is properly nourished for twenty-four hours. If the Wolff-Lehmann Standard called for 1.5 pounds of digestible crude protein, and we provided five pounds, we would not be providing a balanced ration. Again, more than the necessary carbohydrate requirements might be fed, which unbalances the ration.

A balanced ration is one in which all the ingredients — protein, carbohydrates, fats, ash elements and water — are supplied in proper proportions. When any nutrient is supplied in excess, or in insufficient quantity, then we have an unbalanced ration. Under these conditions we cannot hope to get the best returns, as was indicated in the experiment, page 212.

How may feeds be combined so that we have a balanced ration? This often requires patience, several trials, and more patience. Let us try to balance a ration for a cow giving 11.0 pounds of milk. Let the trial ration be composed of:

25 pounds of corn silage.
5 pounds of bran.
5 pounds of alfalfa.
3 pounds of corn.

In balancing the ration we take proportional parts of the digestible composition which is shown in the table on page 208.

FIRST TRIAL RATION

	Dry Matter Lb.	Protein Lb.	Carbohydrates, Lb.	Fats, Lb.	N. R.
25 lb. silage equals $\frac{1}{4}$ of the composition of 100 lb., or . . .	4.4	0.27	3.75	0.175	
5 lb. bran equals $\frac{1}{20}$ of 100 lb. or	4.49	0.62	2.08	0.150	
5 lb. alfalfa equals $\frac{1}{20}$ of 100 lb., or	4.57	0.53	1.95	0.047	
3 lb. corn equals $\frac{3}{100}$ of 100 lb., or	2.68	0.21	2.03	0.138	
Total	16.14	1.63	9.81	0.51	1 : 6.7
Wolff-Lehmann requirement for cow giving 11 lb. milk .	25.00	1.6	10.00	0.30	1 : 6.7
Excess	−8.86	0.03	−0.09	0.21	

The above ration is adequate in all points but one. It lacks 8.86 pounds of dry matter, which could be remedied by adding some oat straw, which is a fairly good feed. So let us change the ration slightly and add some oat straw. And we will try again to approach the Wolff-Lehmann requirements with the following ration:

SECOND TRIAL RATION

	Dry Matter	Protein	Carbohydrates	Fats	N. R.
25 pounds corn silage . . .	4.4	0.27	3.75	0.17	
10 pounds oat straw	8.85	0.10	4.26	0.09	
5 pounds alfalfa	4.57	0.53	1.95	0.04	
2 pounds bran	1.84	0.63	0.51	0.15	
2 pounds cotton-seed meal .	1.78	0.24	0.82	0.06	
Total	21.44	1.77	11.29	0.51	1 : 7.0
Wolff-Lehmann requirement .	25.00	1.6	10.00	0.30	1 : 6.7
Excess	3.56	0.17	0.11	0.21	

This ration still shows a shortage of 3.56 pounds of dry matter and all the rest of the numbers approximate very closely the standard. The differences are not important for they are small, and the N. R. agrees fairly well with the standard. Therefore we may consider the above ration properly balanced, for it meets the needs of the cow. Although, slightly more dry matter might be provided in the ration.

Some factors influencing the value of a feed. — In purchasing feeds the feeder of live stock or poultry is often at a loss to know what feeds to buy. We would say that first of all it depends upon what feeds are on hand. If corn, corn silage, oat straw, and other carbonaceous feeds are on the farm or in the bin, then a feed rich in nitrogen, like cotton-seed meal, tankage, or alfalfa hay, may be purchased, for these would serve to balance the ration to some extent. Of course it also depends upon the suitability of the feed. For illustration no one feeds tankage to cattle, nor is cotton-seed meal fed to hogs except in small quantities and for short periods. So the suitability of the feed is an item which must be considered.

The factors measuring the usefulness of a feed are:

1. Its digestibility.
2. Its nutritive ratio.
3. Its heat producing ability.
4. Its bulk partly.
5. Its manurial value.
6. The composition of the nutrients of a feed,
7. And its cost.

Each will be briefly discussed.

1. The value of a feed is influenced by its digestibility. Again looking at the table on the digestible composition of feedstuffs, and noticing the column which shows the total digestible nutrients in each 100 pounds, we see that corn silage has 17.7 pounds and dent corn has 85.7 pounds. It will also be observed that all the hays given have approximately 50 pounds of digestible nutrients

per each 100 pounds; while oats, wheat and corn have roughly 70, 80 and 85 pounds respectively. Some plants and feeds are hard and fibrous, and hence have a relatively small value as a feed. It will be worth while to study the table closely, comparing the total digestible ingredients per each 100 pounds of feedstuffs.

2. The nutritive ratio is an important factor affecting the usefulness of a feed. Oat straw has a N. R. of 1 : 44.6, which is very wide. Oat straw is a valuable feed when supplemented by a small amount of cotton-seed meal, N. R. 1 : 1.4. This combination makes a pretty good ration for maintaining and roughing stock through the winter. If you ask for prices you will find that feeds having a narrow N. R. are more expensive. Those feeds that are cheapest and will balance the ration should be purchased.

3. The heat producing ability of a feed is also an important factor in determining its value. This is an especially important consideration for winter or cold conditions. The fuel value of 100 pounds of various feedstuffs is as follows:

	Therms[1]
Anthracite coal (for comparison)	358
Timothy hay, 15% moisture	175
Oat straw, 15% moisture	171
Corn meal, 15% moisture	171
Linseed meal, 15% moisture	196
Pure fats	422
Pure carbohydrates	186
Pure digestible proteins	263

Corn is an excellent feed to keep animals warm because it is rich in carbohydrates and fats, and has a high percentage of digestible ingredients. A clean dry stable with plenty of good bedding is a large factor in reducing the food required by animals for fuel purposes.

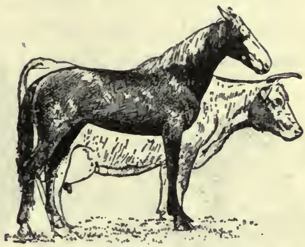
4. The value of a feed often depends to some extent upon its bulk, and vice versa. Corn silage, hays, the grasses, root crops, etc., are the roughages, and besides their composition they furnish

[1] A therm is the amount of heat required to raise one thousand pounds of water nearly 4° Fahrenheit.

bulk to the ration. It is because a ration must have bulk that dry matter is included in the Wolff-Lehmann standards. One reason why shelled oats is an excellent feed for a horse is that it has about 30 per cent hull.

Concentrates, such as the grains and legume seeds, and many of the commercial feedstuffs are valuable on account of their lack of bulk. Feeding both kinds of feeds, concentrates and roughages, will usually give best results.

5. One way to measure the usefulness of a feedstuff is by its manurial value. See the table on page 183. It may be noticed that a ton of alfalfa has a manurial value of $8.84, bran $10.79, cotton-seed meal $23.70, corn silage $1.45. If bran and alfalfa can be purchased for the same money and they have the same feeding value, bran is to be preferred because it has a greater manurial value by about two dollars. Corn silage has little fertility value, while cotton-seed meal has a high fertility value. The manurial value is usually in almost direct proportion to the feeding value.



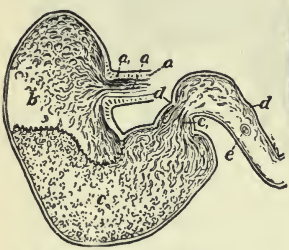
Courtesy Orange Judd Pub. Co.

FIG. 76.—The above figure shows the body capacity of horses and cattle. It is the main reason why horses are fed more concentrated feeds and cattle more roughages.

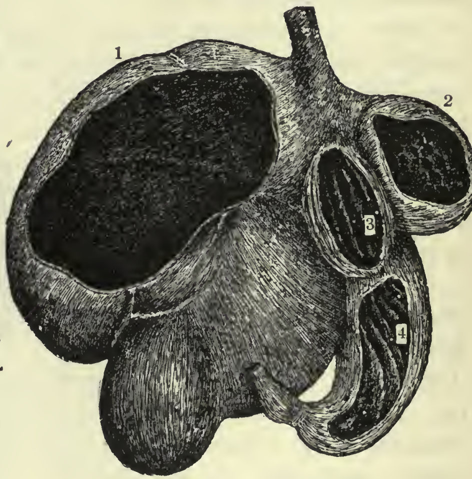
6. The composition of the different nutrients in a feed affects its feeding value to some extent. Casein in milk has a higher feeding value than gluten in corn, although both are protein substances. A balanced ration coming from the cereal kingdom will not make pigs grow as well, or cause hens to lay as many eggs, as if the ration is balanced with tankage. This is probably due to the fact that tankage provides the proper things in its protein make-up in a more balanced or suitable form.

The third table in this chapter indicates that corn contains 0.2 pound of lime in a thousand pounds and 6.9 pounds of phosphorus. Alfalfa has 19.5 pounds of lime and 5.4 pounds of phos-

phorus. This shows that the ash ingredients are found in different feeds in different proportions. This is also an important factor in the feeding value, for in milk production and in growing animals both must be provided. Therefore, since alfalfa and bran are quite similar in all other respects, the mineral composition may become the determining factor in the purchase of these feeds, for two thousand pounds of each feed will bring better returns than four thousand pounds of either. Some people say feed a variety. That depends upon the composition of the ingredient that makes up the feeds.



a, a, a. End of esophagus.
b. Forestomach.
c. True digestive part.
c. Pyloric orifice.
d. Duodenum.
e. Orifices of bile and pancreatic ducts.



1. Rumen or paunch, storage organ.
2. Reticulum.
3. Manyplies.
4. Abomason or true stomach.

FIG. 77. — The left a simple stomach such as the horse and pigs have. The right a compound stomach such as cattle and sheep have. The simple stomach is adapted to the digestion of relatively greater proportions of concentrates, but the compound stomach is especially suited to digest roughages.

7. The cost of a feed affects its economical value. The feeding value of a feed remains the same regardless of its price. Bran dropped fifty cents a hundred yesterday. Its feeding value was not changed a particle.

The price of every ration should be figured, and it may be quickly done as follows, taking the current prices.

Cost of the Daily Ration of a Dairy Cow

	Price per Ton	Price per 1000 Lb.	Price per 100 Lb.	Price per Pound	Total Cost of Ration
40 pounds silage . . .	$ 4.00	$ 2.00	$0.20	$0.002	$ .08
10 pounds oat straw .	10.00	5.00	0.50	0.005	.05
5 pounds bran . . .	30.00	15.00	1.50	0.150	.075
5 pounds alfalfa . .	16.00	8.00	.80	0.008	.04
2 pounds cotton-seed meal	40.00	20.00	2.00	0.02	.04
Total cost					0.285

The cost of this ration is 28.5 cents, and the bran cost 7.5 cents of the amount, or more than one-fourth of the entire ration. Would it not be better to reduce the bran in the above ration on account of cost?

The question naturally arises: What is corn silage worth when timothy hay is selling for $16.00 per ton? What is the relative feeding value of bran and alfalfa? Wheat and corn? etc. The composition and N. R. of the feeds, and the feeds already on hand will determine this to some extent.

Cost and feeding value are the two big factors measuring the usefulness of a feed.

Summary. — Feeding well and economically is one of the important things in making the farm pay. A study of the composition of feeds, and of animal bodies, and of the requirements of different animals for different purposes aids greatly in solving this important question. A balanced ration in all of its constituents usually brings the best and most economic returns. The water content, the digestible crude protein, the fats and carbohydrates, and the composition of the ash ingredients should be carefully considered if feeding is to be done well.

The factors measuring the usefulness of a feed are its digestibility, nutritive ratio, heat producing value, manurial composition, the composition of the different nutrients of the feed and the cost. All of these factors deserve consideration in the purchase and production of feeding stuffs.

QUESTIONS

1. What is the composition of five feeds?
2. What is the function of the different compounds in feeds?
3. What are the food requirements of horses doing medium work? Growing swine? A cow giving 11 lb. of milk?
4. What is the meaning of nutritive ratio? How is it found?
5. What is the meaning of narrow and wide nutritive ratio?
6. Name two nitrogenous and two carbonaceous concentrates; roughages.
7. Discuss the factors which influence the value of feeds.
8. What is the price of ten feeds per ton, per one hundred pounds, and per pound?
9. Compare the cost and composition of bran and alfalfa; milk and potatoes; corn and wheat.

PROBLEMS

1. Balance a ration for a horse doing heavy work.
2. Estimate the cost of feed required to feed annually the animals found upon some farm.

REFERENCES

Henry and Morrison, Feeds and Feeding.
Harper, Animal Husbandry for Schools.
Bailey's Cyclopedia, Vol. III.

CHAPTER XVI

THE HORSE

Value of knowing the horse. — Every boy and girl should try to learn to appreciate all types of live stock and especially the horse. In order to appreciate a horse we must know what the work of the different types of horses is, and what kind of conformation a horse must have in order to do its work most efficiently. It is for this reason that we should try to become good judges of horses. If we are to be good judges of horses we must have the knowledge of what constitutes a good horse and be quick to see variations from a correct conformation. The faculty of judging quickly and well is an attribute of the human mind which comes from experience and training. It challenges the best thought of the brightest boys and girls and men and women. It shall be the purpose of this chapter to present such topics pertaining to horses as will help every one who studies it to become a better judge of horses.[1]

Importance of the horse. — According to the estimate of the U. S. Department of Agriculture there were 21,534,000 horses and 4,925,000 mules in the United States, January 1, 1919. This is a greater number of horses and mules than we have had at any previous time in the history of the United States. The average price of horses in the United States, January 1, 1919, was $98.48 and of mules $135.59.

It has been held by some that tractors and automobiles would cause the horse to become extinct. This has not occurred, nor will it occur, for there are a great many situations in which the

[1] For score cards used in judging light and draft horses, and for the measurements of the parts of light and heavy horses that should be measured for contrast reasons, turn to the Gehrs and James laboratory manual entitled *One Hundred Exercises in Agriculture.*

horse has the advantage over the tractor or the automobile; namely: (1) It is not economical for the farmer with small fields to own a tractor. (2) Muddy roads are unsuited to the automobile. (3) Horses are better suited to deliveries where the stops are close together. (4) The horse works efficiently in cold and warm weather alike.

Parts of a horse. — A general knowledge of the skeleton and parts of the horse will help us in speaking more intelligently about him. The following cut shows the different parts of the horse.

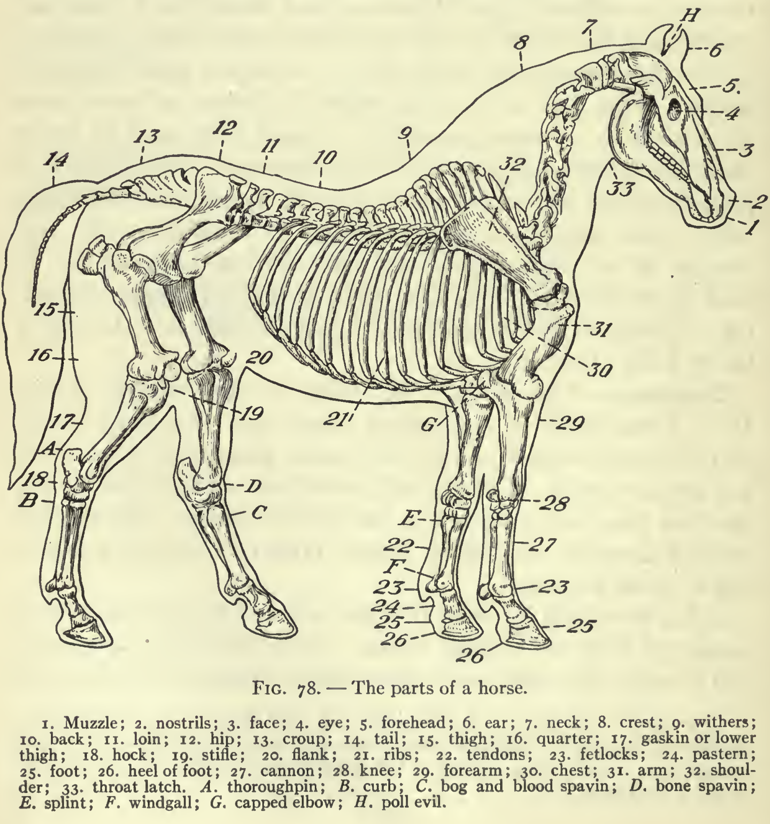


FIG. 78. — The parts of a horse.

1. Muzzle; 2. nostrils; 3. face; 4. eye; 5. forehead; 6. ear; 7. neck; 8. crest; 9. withers; 10. back; 11. loin; 12. hip; 13. croup; 14. tail; 15. thigh; 16. quarter; 17. gaskin or lower thigh; 18. hock; 19. stifle; 20. flank; 21. ribs; 22. tendons; 23. fetlocks; 24. pastern; 25. foot; 26. heel of foot; 27. cannon; 28. knee; 29. forearm; 30. chest; 31. arm; 32. shoulder; 33. throat latch. *A.* thoroughpin; *B.* curb; *C.* bog and blood spavin; *D.* bone spavin; *E.* splint; *F.* windgall; *G.* capped elbow; *H.* poll evil.

The conformation of bones determines to a large extent the action and power of a horse. The draft horse has large, heavy, rather straight bones; while light horses have slender, light and more oblique bones. Length of stride is largely dependent upon obliqueness of pastern and shoulder, and the length of each. Straight shoulders and pasterns give greater power but slower movement. A driving horse which is driven upon pavements should have a conformation of skeleton that will enable him to travel with ease to himself and to the driver. Trueness of action is dependent upon the attitude or straightness of the limbs. The

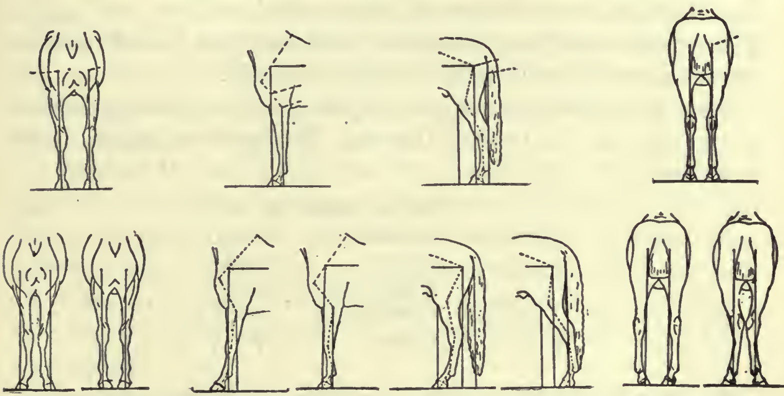


FIG. 79. — The upper pictures show correct conformation that gives trueness of action; the lower pictures show incorrect conformation that can only produce action which is not true.

correct and incorrect attitude of the limbs is shown in the above cut. Limbs of correct attitude possess more strength; crooked limbs lack strength.

Score cards of the different types of horses give descriptions of the external parts of the horse, and may be studied and applied in judging horses and in getting a correct notion of the different parts of the horse.

How to tell the age of a horse.—It is important that we know how to tell the age of a horse, for the market value of a horse depends to a large degree upon age. Horses are worth most and

bring the best price from five to eight years of age, but they possess the greatest endurance from eight to eleven years of age. Horses have two sets of teeth, a temporary set and a permanent set. The temporary or milk teeth make their appearance when the colt is two to eight weeks old. The temporary teeth disappear and the permanent ones make their appearance at about the following ages. Corresponding teeth of the upper and lower jaw appear at the same time.

1. Middle incisors appear at the age of $2\frac{1}{2}$ to 3.
2. The intermediate incisors at the age of $3\frac{1}{2}$ to 4.
3. And the corner incisors at the age of $4\frac{1}{2}$ to 5.

The appearance of the permanent teeth serves as a basis then to tell the age of the colt until he is five years old.

After the age of five we can tell the age by the disappearance of the cups in the teeth. The cups disappear in regular order as follows:

Lower jaw	Middle incisors	$5\frac{1}{2}$–$6\frac{1}{2}$.
	Intermediate	$6\frac{1}{2}$–$7\frac{1}{2}$.
	Corner	$7\frac{1}{2}$–$8\frac{1}{2}$.
Upper jaw	Middle incisors	$8\frac{1}{2}$–$9\frac{1}{2}$.
	Intermediate	$9\frac{1}{2}$–$10\frac{1}{2}$.
	Corner	$10\frac{1}{2}$–$11\frac{1}{2}$.

The rapidity with which the cups disappear may vary some, since it is dependent upon the kind of feed fed, the texture and the substance of the teeth, and the disposition of the horse.

After a horse is twelve years old it is impossible to tell his exact age. Condition and care after a horse is twelve years old determine its value to a greater extent than the exact age. In old horses the teeth become very slanting, due to age and pressure upon the teeth.

Blemishes, unsoundnesses and diseases of horses. — We should know something about the defects of horses if we are to become good judges of them. Blemishes are defects which do not interfere with the action or functioning of the part affected. Unsoundnesses are of such a nature that they interfere with the

action or work of the horse. Diseases irritate the parts affected. Some diseases are temporary and others are permanent. The line of demarkation of blemishes, unsoundnesses and diseases is not always clear, for they may overlap. A brief discussion of the defects of horses follows. Examining the horse systematically, the parts of the head, the neck, the forequarters, and the hindquarters, aids in detecting defects.

There are several defects of the eyes, namely, total blindness, moonblindness and pink eye. *Total blindness* is easily observable, and needs no discussion here. *Moonblindness* is prevalent mostly during wet weather, and although the cause of the disease is not well known it is probably due to moist conditions. Providing dry quarters is probably the best prevention and cure for moonblindness. *Pink eye* is often seen in horses about livery stables. It is a contagious but not a serious disease.

Distemper is a bad cold of the horse, and affects the nasal passage. It is a highly contagious disease, and isolation is the first step in the prevention of the spread of the disease. A warm, comfortable, dry, sunny stable with good wholesome food will help the horse to recover from distemper. *Glanders* is a fatal disease to both the horse and man. It is communicable from the horse to the man.

Poll evil is caused by bruising the poll. This blemish causes the poll to become sensitive, and when it is touched, as in putting on a bridle, the horse may pull back because of pain in the part affected. If the blemish is caused by a low stable ceiling it may be remedied by removing the cause.

Fistula is an enlargement of the withers caused by a bruise. A horse in rolling may hit a rock or hard soil which may cause the initial irritation. If this is continued the disease will become well established. If it is in an aggravated form, it should be lanced at the lowest point so that all the pus it contains will drain naturally.

Sore shoulders, or collar boils are caused by an ill-fitting collar, or by hames placed too low on the collar. Either of these

will cause undue pressure to be placed upon the few square inches of the shoulder point. A good driver will not use a horse in heavy work with an ill-fitting collar, for neither the master nor the horse can do efficient work.

Sweeny. — The symptom of sweeny is a shoulder with the muscles shrunk away, leaving the shoulder bare and flat appearing. The muscles and skin have grown tight to the shoulder blade.

Capped elbow, often known as a shoe boil, is found on the elbow and is often caused by the horse hitting the elbow with the rear foot or shoe upon lying down. It is not a serious defect and does not interfere with the work of the horse.

Buck knees are caused by hard work and by an improper tension of the tendons in the front and rear of the front legs. There is no cure for this unsoundness. A calf knee is a bending back of the knee.

Splints are bony deposits usually found at the end of the splint bone, but not always. Sometimes they are near the tendon. They may often be seen and can usually be felt with the hand. A splint near the tendon often interferes with the action of the horse, and is the worst form of splints. There is no cure for this evil, though in colts it often disappears.

Scratches appear on the rear depressed portion of the pastern. Scratches are due to unclean wet stables, and the symptoms may be seen in a rough, chapped condition of the skin. A bad case of scratches is often known by the term grease heel. Providing clean, dry quarters and washing the part affected with clean, well-boiled salt water will help much in healing the skin.

A cocked ankle is similar to a buck knee. Wind puffs appear usually just above the ankle joint.

Ring bones and *side bones* appear just above the hoof. Side bones appear on the sides of the foot, and ring bones extend around the foot. There are two forms of side bones, high and low. These defects are unsoundnesses, for they interfere with the action of the coffin joint. Ring and side bones may be detected by running the hand over the affected part and often by the action of the horse.

Quarter and sand cracks appear on the rear quarter and on the front part of the hoof respectively. They are often due to poor hoof texture. These defects do not seriously affect the work of a horse provided he is well shod.

Corns are caused by ill-fitting shoes, and by leaving the shoes on too long. As the foot grows out it gets larger. But strong shoes may tend to contract the foot and put undue pressure upon its sensitive parts. This causes corns. Horses with corns do not walk well, and if the part affected is hit with a hammer the horse will flinch. The shoe should be made to fit the foot, and not the foot the shoe.

Thrush is caused by a bruise of the frog of the foot, and may be detected by the odor emitted. The affected part should be thoroughly cleaned with a knife and washed with a five per cent carbolic acid solution.

Knocked down hip is caused by the horse running against something with the entire impact of the body and dislocating the hip joint.

Stifles appear on the stifle joint and are similar to shoe boils. There is no cure for stifles.

Defects of the hock. — Defects are more frequently found on the hock than on any other portion of the horse.

Fig. 80. — A capped hock.

A capped hock is caused by a bruise and affects the skin over the hock only. *A curb* appears on the rear of the leg about three or four inches below the hock. A curb shows a weakness of the hock and is a more serious blemish than a capped hock. *A thoroughpin* appears as an enlargement about the size of a walnut in the depressed section just above the hock and between the tendon and the leg. It consists of a soft swelling which may be pushed back and forth with the hand. It is not a serious defect. Bone and blood spavins are defects that lower the working value of a horse greatly. *Bone spavin* occurs as an enlargement on the

inner side of the hock. It may be most easily seen by standing in front of the horse and observing the outline of the hock joint. It interferes with action and is a serious defect. *Blood spavin* is an enlargement of the blood vein on the inner and front part of the hock. The oil of the joint and the blood accumulate and form a soft swelling. Blood spavin is not an unsoundness, for it does not interfere with the action of the horse.

A jack is an enlargement of the bone on the rear cannon. It usually occurs on the outside of the cannon bone. There is no cure for this blemish.

Heaves is a disease caused by the muscles around the air cells of the lungs losing their elasticity. Dust from hay or from other sources may accumulate in the lungs and in the air sacks of the lungs, so that it cannot be expelled. This dust sticking to the interior lining of the air sacks soon causes them to function improperly — a breakdown in the muscles of the walls occurs and the horse has the heaves. Exhalation of the air cannot be controlled, but the air from the lungs escapes suddenly due to the sudden collapse of the muscles of the air cells. Although the disease is seldom cured it may be alleviated by moistening the hay when fed, so that the dust will not be inhaled, but swallowed.

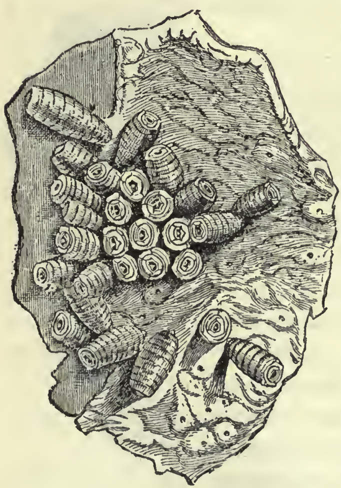


Fig. 81. — The larvæ of the botfly. They reduce the vigor and life of the horse.

Bots are due to the botfly. The botfly deposits its yellow eggs in the inner cannon of the front limb and under the throat latch. Upon hatching the larvæ of the botfly set up an irritation and the horse tries to bite them off. Consequently some of the larvæ are swallowed and carried to the stomach,

where they remain for eight to ten months, adhering to the lining of the stomach and securing their food there. Combat the botfly by preventive measures by washing the deposited eggs with kerosene.

Colic is usually caused by a collection of gas in the alimentary tract of the horse. The distention of the tract causes pain. The horse will lie down and rise again, which is a symptom of the disease. Allow the horse to roll or lead him about. Give tablespoonful doses of baking powder in hot water as a drench, being careful to pour the drench down the æsophagus and not down the trachea.

Founder, usually occurring in the front feet, is probably due to a disturbed or poor circulation, heavy concussion, drinking cold water, and to a lack of tone of body condition. The front feet become feverish, and the feet may in aggravated cases become swollen. A competent veterinarian should be called to treat the disease.

Types of horses and mules. — There are four types of horses and mules, — namely: draft, coach, light, and pony types. The draft type of horse is heavy, compact, and rather slow, and works efficiently only in the *walk*. The weight ranges from 1500 pounds upward. The draft type has a body which is half of the height of the horse at the withers. The measurements are about as follows:

Length of head	30 inches.
Length of shoulder	26 inches.
Height of shoulder	66 inches.
Heart girth	85 inches.
Width through breast	20 inches.
Width over hips	26 inches.
Length of forearm	17 inches.
Length of cannon	$10\frac{1}{2}$ inches.
Angle of pastern	45 degrees.
Distance around front cannon	$9\frac{1}{2}$ inches.

The coach type is as tall as the draft type, but more rangy, and weighs 1100 to 1500 pounds. The coach horse is so constructed that he is capable in the *trot*. He should be able to go a

long distance in a trot. This is the test of the coach type. A gaited coach or draft horse is not desired.

Light horses comprise several breeds, each of which has a slightly different function to perform, and hence the characteristics cannot well be mentioned here for they differ in different breeds. The qualities of each of the light horse breeds will be discussed in a

Courtesy The Percheron Review.

FIG. 82. — Carnot (66666). A typical Percheron horse in conformation, constitution, color and carriage. Note the character, quality and fine temperament represented in the above picture.

later paragraph. For a discussion of ponies the reader is referred to supplementary books.

Breeds of horses. — The breeds of draft horses, coach horses and light horses will be discussed in the order named.

1. The Percheron horse.—The French government gave substantial aid in the improvement of this horse. It offered to subsidize good breeding stock, and to this end horses were clas-

sified in three classes by competent veterinarians. *Subsidized* horses received an annual bonus of \$60 to \$100; those in the second class, known as *authorized* horses, received \$60; and *approved* or common horses were discouraged. In addition, the government established two breeding stables; one at Le Pin in 1714, and the other at Pompadour in 1755. These breeding stables have helped greatly in improving and stabilizing the Percheron horse. Shows and competitive fairs have also had a part in this work, as have also the efforts of the Percheron

Courtesy The Percheron Review.

FIG. 83. — Imprecation 79304 (79214). A typical Percheron mare.

Breed Organization, which was organized in the United States in 1876 and in France in 1833. Nor should we forget the credit due to the Arab horse, whose excellent qualities of intelligence, constitution, good feet and fine form have gone into the improvement of the Percheron.

The Percheron horse is a typical draft horse, usually black, gray, or white in color, having smooth fetlocks and possessing

the following strong points: (1) Style and good action; (2) A strong constitution and endurance; (3) Good disposition and temperament; (4) Good feet; (5) Superior ability to pull big loads.

2. *The Clydesdale horse.* — The Clydesdale is the draft horse of Scottish origin, having a definite history since 1720. Clydesdales were first imported into the United States about 1842.

FIG. 84. — A Suffolk stallion.

Clydesdale horses are generally brown and black, with white markings. Their bodies are somewhat cylindrical and not very deep. Their shoulders and pasterns are sloping, which protects the feet and shoulders from concussion, and gives them superior action. The Clydesdale is 100 to 150 pounds lighter than the Percheron horse, weighing 1750 to 2000 pounds.

3. *The Shire horse* originated in England, as early as the Roman Conquest, 44 B.C. However, the real improvement of these horses has come within the last one hundred years. They were first imported into the United States in 1836. To-day they are found in all the English-speaking nations.

Shire characteristics are those of the best draft type. They are heavy and massive and have very strong limbs. They are

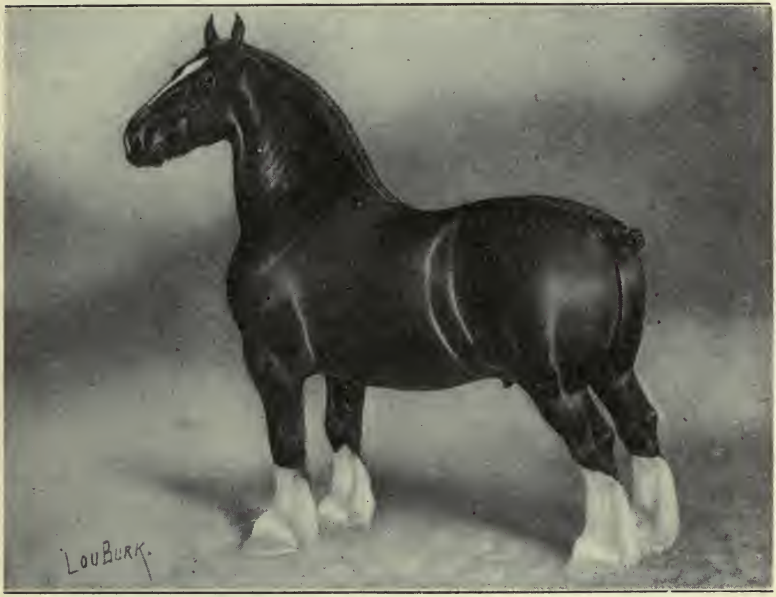


FIG. 85. — A fine specimen of the Shire breed. Note the color and color markings, long hair on the fetlocks and the compactness and power of the horse.

usually black and brown in color with white stocking feet. They weigh 1600 to 2100 pounds, and the best breeders pride themselves upon one ton horses. The mane, tail and heavy, hairy fetlocks extending to the knees and hocks, characterize the breed. Their feet are said to be somewhat flat. Their strong points are weight and strength. High prices have been paid for Shires.

4. *The Belgian horse* is the draft horse of Belgium. Belgian horses are short, chunky and compact and weigh more for their

Courtesy U. S. Dept. of Agriculture.

FIG. 86. — A Belgian mare.

size than any other draft breed. Belgium has excellent laws to protect and induce the people to improve the Belgian horse.

5. *The Suffolk (Punch) horse* originated in Suffolk county, England. It is the smallest and in action ranks first among the draft horses. It is chestnut in color. It seems probable that draft horses are the last horses that will be replaced by machinery, and that they will bring the farmer better money than any other type of horse. See figure 84.

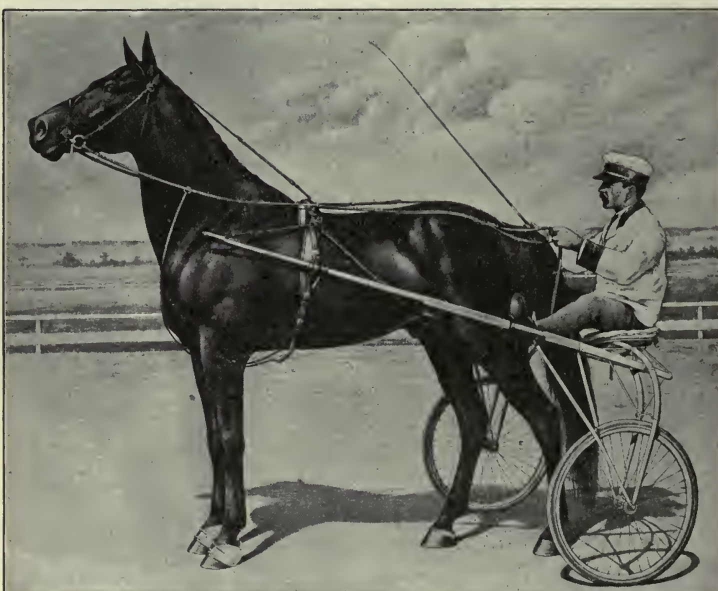
Coach horse breeds includes the Hackney, Cleveland Bay, French Coach and the German Coach. The coach horses range from 15 to 16½ hands in height and weigh from 1000 to 1500 pounds. The Hackney and French Coach are noted for high knee and hock action, while the Cleveland Bay and the German

Coach horse have been developed more along the line of utility and capable action in the trot. The long steady *trot* is the gait the coach horse must be able to go.

FIG. 87. — A Hackney Coach horse. Note the beautiful curves and the spirit of the horse.

Light horses. — The light horses comprise the English Thoroughbred, the Standard Bred Trotter and Pacer, the American Saddle Horse and the Arabian and Orloff Trotter. The English Thoroughbred is the running horse of England. The horse jockey weighing about 110 pounds is the rider of the English Thoroughbred. The term "Thoroughbred" is often confused with "pure bred." The

word "Thoroughbred" refers to the English running horse only, while the term "pure bred" refers to any animal or fowl that is bred pure. The Standard Bred Trotter is the horse that performs at the trot against time, or in a race. Any horse that can trot a mile in 2:30 or better may be registered as a Standard Bred Trotter. A Standard Bred Pacer must go a mile in 2:35 or better. The



Courtesy Ginn and Co.

FIG. 88. — Dan Patch, holds the World's Pacing Record, 1:55¼.

American Saddle Horse is either a three-gaited or a five-gaited horse. He does not compete against time. He is principally for show and beauty. The American Saddle Horse is full made, as the following cut shows, and is a horse of beautiful lines and curves. The three-gaited American Saddle Horse must perform at the walk, trot and canter. And the five-gaited horse must go two of these additional gaits, running walk, fox trot, or slow pace.

Courtesy of Show Horse Chronicle, Lexington, Kentucky.

FIG. 89. — Rex McDonald 833. An American Saddle Horse, showing the beautiful form, the stylish carriage of head and tail and the intelligence of this breed.

The market classes of mules. — There are five market classes of mules: (1) The plantation mules are of two kinds, the sugar plantation mule and the cotton mule. Sugar plantation mules are 15 to 17 hands tall, and weigh 1100 to 1500 pounds. They are better than other mules in quality, style and action, and bring the highest prices. The cotton mules range from $14\frac{1}{2}$ to $15\frac{1}{2}$ hands, and weigh 850 to 1100 pounds. They have medium sized bones,

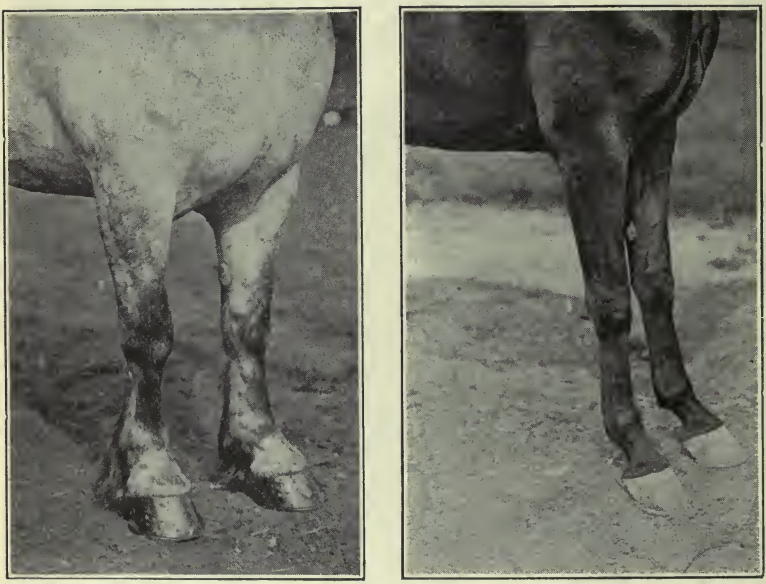
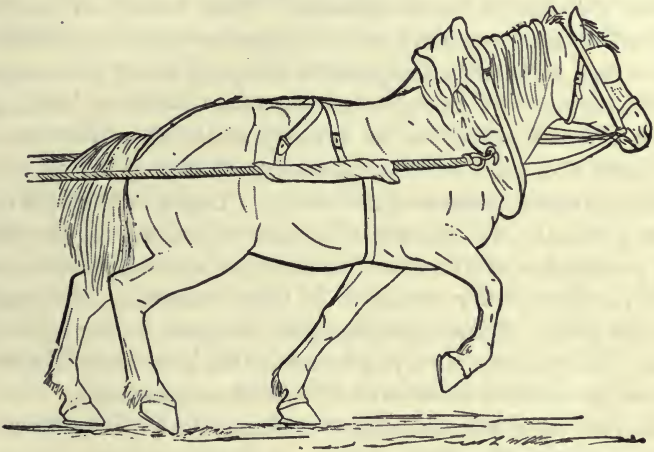


FIG. 90. — Strength and speed. Contrast the strength, width of breast, shortness of pastern, etc., of these two pictures.

are compact, and of good style. (2) The lumber mules range from $15\frac{1}{2}$ to $16\frac{1}{2}$ hands, weigh 1250 to 1600 pounds, and possess more ruggedness and bone than do the sugar mules. (3) Railroad mules are the same height as lumber mules but weigh a little less. Substance and stamina are essential points of these mules. (4) Levee mules are about the same as railroad mules, but possess a little more substance, and can do harder work. They are used

as draft animals. Soundness and working ability are emphasized. (5) The mining mules are $12\frac{1}{2}$ to $14\frac{1}{2}$ hands high and weigh about 700 to 900 pounds. They must possess rather heavy bones and be rugged in order to do the work in the mines. Prices vary, but the mining mules and cotton mules are generally the lowest priced. Mules belonging to the other classes have a ready sale and bring good prices.

Factors influencing the work of the horse. (1) *Conformation and type.* — Conformation is one of the important factors affecting



Courtesy J. B. Lippincott Co.

FIG. 91. — Traces at rear should be about 8 inches lower in order that the pull on the collar is neither up nor down but at right angles.

the work of the horse. In other words, form and function with the horse, as well as with other animals, go hand in hand. A draft type of horse cannot do the work of a light horse efficiently, nor can the light horse do well the work of the draft type. Neither one is fitted in conformation, weight, temperament and action to do the work of the other type.

2. *Fit of harness.* — The attachment of traces to harness should be at right angles. If the traces pull up or down on even a well-fitting collar the horse cannot do his work comfortably and well.

The traces should be attached to the harness at such a point that the burden is evenly distributed along the collar line.

3. *Kind of wheel.* — High wheels decrease the draft while low wheels increase it. *High wheels* will go over a rock or travel over a rough road much more easily than a low wheel. *Wide tires* also decrease the draft. However, on very soft roads they may be a disadvantage.

4. *Rate of movement.* — A draft horse can travel in the walk from 2 to $2\frac{1}{2}$ miles an hour and at the same time pull a heavy load. When the draft horse is constantly being forced to overreach himself or made to travel at an unnatural gait, his efficiency is cut in two, and the feed required is increased about 50 per cent.

5. *Exercise.* — Exercise is an important factor in keeping the horse in condition so that he is ready at any day to do his work well, and do a lot of it. The Arabs have a saying, "Rest and fat are the greatest enemies of the horse." This is very emphatically true, and is also true of every other class of animal, for the fattening process is a strain upon the digestive and circulatory organs. The pampered show animal is in many instances best qualified for the block. Proper exercise keeps the horse in the best condition. Except in extremely bad weather the horse should be turned out in the lot or be exercised for four or five hours daily.

6. *The horse and his master.* — A good horseman knows his horse and the horse knows him. A good horseman will get 25 to 50 per cent more work out of a horse than a poor horseman will, and will do it more easily. A good horseman seldom whips, excites, or worries a horse. He never requires anything of the horse that it is unable to do, but whatever is asked is asked kindly and firmly. The real horseman is a master of the horse — in feed, in work, in treatment and in care and management.

7. *Starting the horse slowly.* — In beginning work in the morning or afternoon allow the horse to walk slowly for eight or ten blocks and gradually work him into the normal speed. This is a factor affecting the work of the horse. To start at full speed a horse that has been worked hard the day before is criminal.

8. *The stable.* — Stables should be roomy, dry, clean, sunny, well bedded, ventilated, and free from direct air currents. They should be provided with simple substantial feeding boxes and interior fixtures. A barn in which the dust is constantly circulating is no better for a horse than for a dairy cow. Good stables prevent disease and blemishes and are a big factor in keeping the horse in condition.

9. *Care and training.* — *Proper grooming* at night rather than in the morning, but both night and morning preferably, contributes to the beauty and condition of the horse. Grooming increases skin circulation and has a special value outside of improving the appearance of the horse. *Blanketing* horses prolongs their efficiency, keeps the cold rain and wind off, and protects the horse from extremely cold temperatures and sudden changes. The feet of the horse should be properly protected. "*No foot, no horse*" is a true saying. Proper shoeing and reshoeing or resetting the shoes about every month should keep the feet in good condition. *The teeth* often do not wear down evenly especially the corner incisors. These should be filed down, an operation which requires only a few minutes but often improves the working temperament of a horse. *Early training* is an important factor in the future usefulness of a horse, for as a colt is trained so will he be. A horse will act in accordance with early training to a greater extent possibly than any other animal, hence the importance of forming and establishing correct habits in the colt.

10. *Proper feeding of a horse* is the tenth important factor in influencing the work of a horse. The Wolff-Lehmann requirements of horses per 1000 pounds of live weight follow:

	Dry Matter Pounds	Protein Pounds	Carbohydrates Pounds	Fat Pounds	N. R.
Light work . .	20	1.5	9.5	0.4	1 : 7.0
Medium work .	24	2.0	11.0	0.6	1 : 6.2
Heavy work . .	26	2.5	13.3	0.8	1 : 6.0

A few rations should be balanced for horses doing light, medium and heavy work. The following is a fair ration for light work.

Timothy hay	10 pounds.
Alfalfa hay	10 pounds.
Corn	$2\frac{1}{2}$ pounds.

For heavy work include some oats and clover hay and in some instances bran, where it is cheap enough. Other rations may be found in Henry and Morrison's book, page 331.

Summary. — The horse is a very important animal, and it is hoped that every person, even if he is not an owner of horses, will have a kindly sympathetic feeling for the intelligence and spirit of the horse. The horse should be placed in work to which his form and temperament are suited. To be able to estimate quickly and well the ability of a horse or mule to do certain kinds of work, or in other words to classify the horse rightly from the standpoint of the market, challenges the intelligence of the best students of horses, and comes only through study and experience. It is hoped that this introductory study will increase the sympathy of the student, and give him some points upon which to build in estimating the working worth and money value of a horse.

The factors that influence the work of a horse are type, fit of harness, character of wheels, rate of movement, exercise and fatness of the horse, attitude of driver, the manner of starting, condition of the stable and the miscellaneous items of grooming, blanketing, care of feet and teeth and proper feeding.

QUESTIONS

1. Discuss the importance of the horse; the tractor; and the automobile.
2. Discuss the relation of the conformation of the horse to action, and blemishes.
3. How do you tell the age of a horse?
4. Describe the causes, symptoms and remedy of five defects of horses.
5. Classify and name the breeds of horses.
6. What are the good qualities of the Percheron horse?
7. Name and describe the market classes of mules.

8. What are the factors that influence the work of the horse?
9. Name the points of a horse score card.
10. Balance a ration for a horse doing light work.

PROBLEMS

1. Report on the shoeing of a horse.
2. Discuss the essentials of a horse stable.
3. Discuss the market classification of horses.

REFERENCES

Gay, Productive Horse Husbandry.
Plumb, Types and Breeds of Farm Animals.
Craig, Judging Live Stock.
Gehrs, Productive Agriculture.
Henry and Morrison, Feeds and Feeding.

Addresses of breed associations of breeds of horses. — These Associations will probably furnish a few copies of their publications to each school. Such publications should become the property of the school library.

Percheron Society of America, Wayne Dinsmore, Sec., Chicago, Union Stock Yards.

American Clydesdale Association, R. B. O'Gilvie, Sec., Chicago, Union Stock Yards.

American Shire Horse Association, Chas. Burgess, Wenona, Illinois.

American Hackney Horse Society, Gurney C. Gire, Hempstead, Long Island, New York.

German Coach Horse Association, J. Crouch, Lafayette, Indiana.

American Saddle Horse Association, Roger Lillard, Louisville, Kentucky.

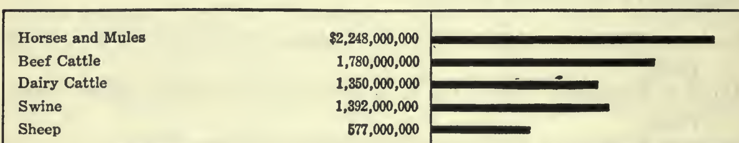
CHAPTER XVII

BEEF CATTLE AND BEEF PRODUCTION

Importance. — The greatest number of beef cattle in the United States in proportion to our population was in 1900, when we had 50,000,000 cattle and 75,000,000 people, or two beef animals to every three persons. In 1910 beef cattle had decreased to 41,000,000 and our population had increased to 92,000,000, or one beef animal to every $2\frac{1}{2}$ persons. January 1, 1918, the number of beef cattle was about 43,000,000 and the population 112,000,000 (estimate), or one beef animal to every 2.6 persons.

Even if the number of beef cattle is decreasing, in aggregate value they compare well with other farm animals. The comparisons are shown in the following graph.[1]

Crop Report Data, January, 1918



Although beef cattle are found in every state of the Union, about 50 per cent are found in the two tiers of states just west of the Mississippi River. Texas ranks first with 5,500,000; Iowa, Nebraska and Kansas each have over 2,000,000; Missouri, California, Wisconsin and Minnesota have about 1,500,000 each; and Illinois, Oklahoma, Colorado and New Mexico have about 1,000,000 each.

It is likely that some of the above named states as well as some not named could afford for immediate returns and permanent agriculture to produce more beef cattle.

[1] Crop Report Data for January, 1918

The advantages of beef production.—The first advantage of beef production is that it tends to maintain the fertility of the soil. Corn farming in the corn states, cotton farming in the cotton states and wheat farming in the wheat producing states gradually but surely impoverish the soil. Mumford, of the Illinois Station, in his book entitled *Beef Production* says, "The animal husbandry department of the Illinois Experiment Station has repeatedly stated in its bulletins that it believes that the manure produced by fattening steers will balance the expense of labor in caring for the cattle."

A second advantage is that thousands of acres all over the United States not now used may be profitably utilized for beef production. According to the 1910 census 54.4 per cent of the land in farms was improved. "Improved land includes all land regularly tilled or mowed, land pastured and cropped in rotation, land lying fallow, land in gardens, orchards, vineyards, and nurseries, and land occupied by farm buildings"; this shows that more than 45 per cent of the farm land in the United States is brushland, rough or stony land, swamp land, or other land not improved. Much of this unimproved land may be well utilized for beef cattle production. "Statistics tell us that only about 40 per cent of the tillable or arable land of the South is being used. Sixty per cent of the land is lying idle and returns to the owner not a cent in wealth. No state can become wealthy when only 40 per cent of the land capital is being used."

A third advantage of beef production is that beef cattle help in solving the labor problem. More pasture land and less acreage of cultivated crops may be one result of beef production. The work required to take care of 20 dairy cows will take care of 100 to 150 beef cattle. Beef steers transport themselves to market. Instead of hauling 11 tons of roughages and grains to market we may drive a ton of beef to market. This saves labor.

In another way beef production may be made to save transportation. For illustration, the South produces a great deal of cotton-seed meal, but few steers; consequently the cotton-seed

meal is marketed in the North, fed to steers, and the finished beef is exported from the North to the South. The South has excellent conditions for beef production. Then why this waste of transportation? Much of it is unnecessary.

Beef cattle utilize profitably the roughages on many farms. On a well-managed farm, where diversification of crop production is practiced, there are roughages such as fodders, cowpeas, soy beans, clover, alfalfa, wheat and oat straw, the grass along streams and fences and aftermaths which may be profitably used by beef cattle.

The valuable cuts. — The way a beef steer is cut up for the retail trade is shown by the following picture taken from Farmer's Bulletin No. 711.

A well-finished 1200 pound steer will dress out about 800 pounds, of which about 700 pounds, after the bones are taken out, is edible meat. Porterhouse steak, prime of rib, sirloin, round steak and rump are the high priced cuts. Some of the other cuts are worth less after the steer is slaughtered than they were when the steer was on foot.

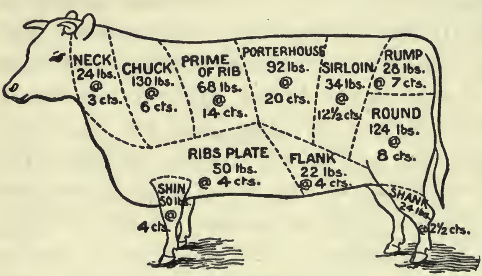


FIG. 92. — Valuable beef cuts.

The cuts of beef animals vary in price (not always in real value) for the following reasons:

1. The high priced cuts are more tender and more palatable than some of the other cuts. They are more tender because the walls of the cells making up these cuts are thinner, and they contain little waste.

2. The low priced cuts are low priced because they often contain a lot of waste tissue in the form of bone (shin and shank), layers of fat (flank), and connective muscular tissue (flank and plate).

3. The public demand distorts the price of the cuts. Housekeepers call mostly for round steak, sirloin, prime of rib, or porterhouse steak. This tends to raise the price of these cuts and to lower the price of the other cuts, for the retail butcher must sell every cut.

4. The cuts that are least exercised and exposed are the high priced cuts. Exposure and exercise make the meat tougher.

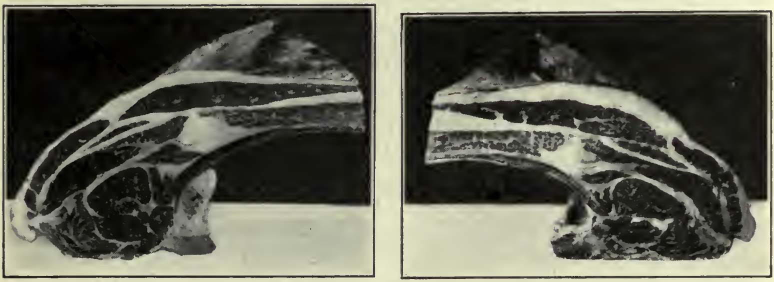


FIG. 93. — Notice the variation of lean and fat in these cuts. There is little difference in their food value, but the prices may vary considerably.

The chemical composition and the calorific value of different beef cuts is virtually the same, and the cuts therefore do not vary as much in real food value as the retail prices indicate. The composition and calorific value of a few cuts follow: [1]

PERCENTAGE COMPOSITION OF BEEF CUTS

	REFUSE	WATER	PROTEIN	FAT	CARBOHYDRATES	ASH	CALORIFIC VALUE PER LB.
Fore quarter	18.7	49.1	14.5	17.5	0.0	0.7	995
Hind quarter	15.7	50.4	15.4	18.3	0.0	0.7	1045
Round steak	7.1	60.7	19.0	12.8	0.0	0.8	890
Porterhouse	12.7	52.4	19.1	17.9	0.0	0.8	1100
Neck . . .	27.6	46.0	14.5	11.9	0.0	0.7	1165
Shank . . .	37.0	43.0	12.8	7.3	0.0	0.6	545
Pork for comparison . .	10.7	48.0	13.5	25.9	0.0	0.8	1320

[1] Farmer's Bulletin, No. 142. Principles of Nutrition and Nutritive Value of Foods.

From the table it is evident that the chemical composition of the various cuts is practically the same; however, the waste is greater in some than in others.

The Beef Type.[1] — There are three classes of people for whom beef cattle are produced, namely, breeders, feeders and consumers. When judging cattle, one should consider the purpose for which they are to be used. The points that feeders, breeders and consumers consider to be essential in a beef type are: (1) form; (2) quality; (3) temperament; (4) constitution; and (5) an even distribution of flesh.

1. The form of a beef type is "brick-like." The top line and the under line are practically straight and parallel. The limbs are set well apart, in order that the sides, shoulder and rear quarters may carry out evenly and well. The typical beef steer has a head which is indicative of a good feeder. The muzzle is box shaped, the nostrils are large, and the head is broad, showing docility. The ears are medium sized and show quality.

A poor feeder, on the other hand, shows a narrow face and nose, a thin neck and chest, slabsided ribs and a poor top and under line. The following picture illustrates such steers.

2. Quality. — Quality refers to the condition of bone, skin and hair. In a good beef type the bone is of medium size; the legs are moderately short, indicating the ability to dress out well; and the skin and hair are soft and pliable and have a mellow touch. Coarse bones, large joints and a thick boardy skin are undesirable attributes in a steer. Rough, open shoulders and prominent hip bones are the indications of inferior quality.

3. The proper temperament of a steer expresses itself in a mild, placid, quiet eye. The steer with a wild eye is usually a poor feeder. A steer of superior temperament is domestic, likes to be near the barn and around the proprietor looking for feed, while the inferior feeder is shy, and is found at the outskirts of

[1] For score cards, used in scoring beef cattle, and for the nomenclature of the parts of cattle, turn to the Gehrs and James laboratory manual entitled *One Hundred Exercises in Agriculture*.

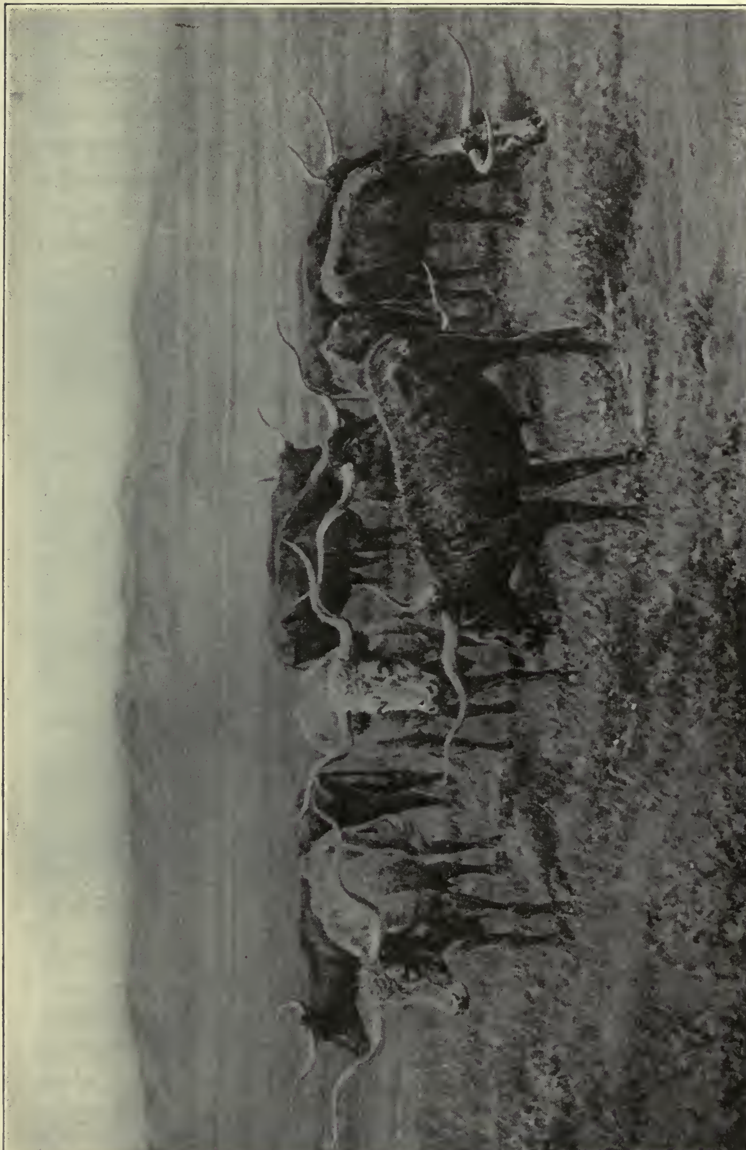


FIG. 94. — A group of scrub cattle. They lack breeding and improvement. They are poor feeders, low in per cent of carcass, and the meat is tough. Almost a relic of the past.

the herd. The good type is quiet and docile, while the poor type is undomestic and wild.

4. The constitution of a good feeder and the best beef type may be seen in a box shaped muzzle, broad, short head, long and well-sprung ribs, and if horns are present they are short and powerful. A slabsided, long faced, cut-up-flanked steer has not the qualities of constitution desirable.

5. The typical beef type is evenly, smoothly and firmly fleshed in the region of the valuable cuts. The flesh over the porterhouse, prime of ribs and sirloin cuts is often patchy. This is a very undesirable quality. The back often lacks straightness. This is a defect and reduces the value of a beef-steer.

The beef breeds. — There are four principal breeds of beef cattle, namely, Shorthorn, Hereford, Aberdeen Angus, and Galloway. Each will be briefly discussed.

1. *Shorthorn cattle.* The counties of Durham, Northumberland and York, England, and a small section of Scotland are the native home of the Shorthorn cattle. Although their origin is somewhat obscure, their characteristics were improved and unified by the following men:

Name	Born	Died	Type of Cattle Developed
Thomas Bates	1775	1849	Dairy beef type
Charles Collings	1749	1836	Beef type
Robert Collings	1750	1820	Beef type
John Booth	1789	1857	Beef type
Richard Booth	1788	1864	Beef type
Amos Cruickshank	1808	1895	Beef type

These great breeders of Shorthorn cattle fixed pretty well the type of Shorthorn cattle we have had ever since.

The Ohio Importing Company, organized in 1833, imported 19 head of Shorthorn cattle. This was the first real importation into the United States. In 1836, at the dispersal sale of this company, 43 head were sold for $34,540, or an average of $803.25

per head. About this time, 1838, Col. Leonard brought the first Shorthorn cattle west of the Mississippi to Missouri. The Shorthorn cattle possessed so many desirable qualities that they were soon scattered over the entire west and later over South America. Their distribution was so widespread that the epithet applied to them was, "The Universal Intruders."

Shorthorn cattle have been used extensively in grading up native cattle. The long horns of the Western cattle were

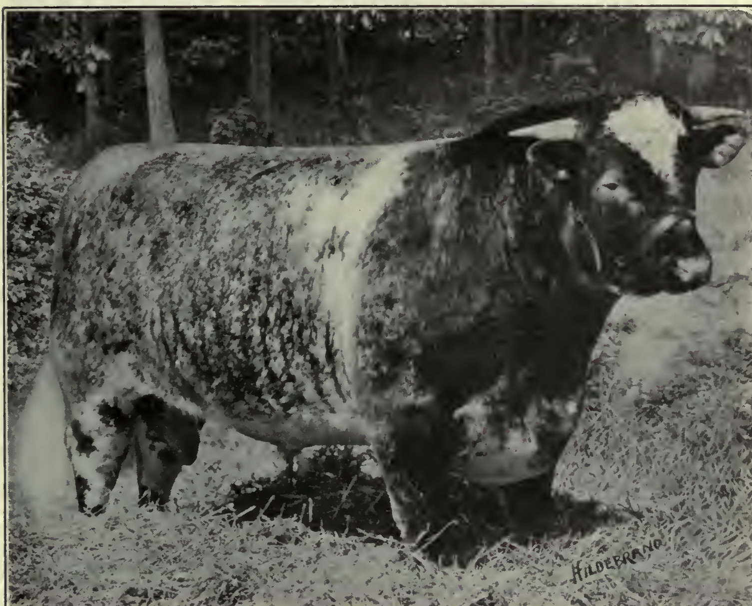
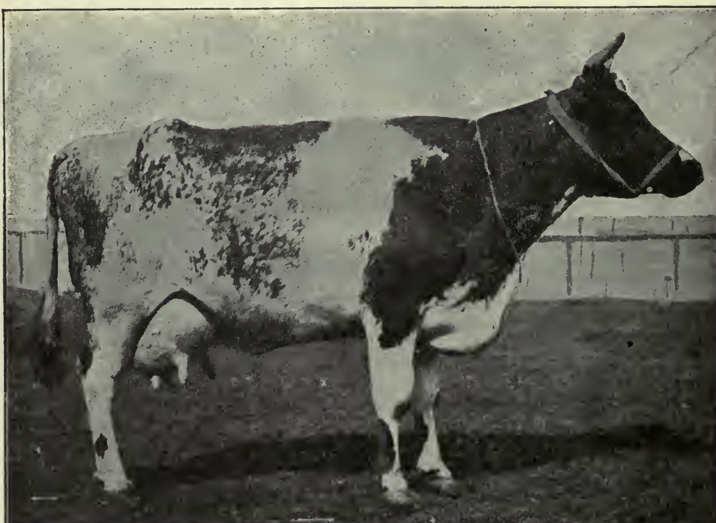


FIG. 95. — A fine specimen of the Shorthorn breed. Note the fine top and underline.

shortened and the slabsided bodies of native cattle were broadened by the use of Shorthorn sires. The quality of the meat, the temperament, the feeding efficiency and the percentage of dressed carcass of the native cattle was greatly improved by the same means. They have helped to make cheaper and better beef.

Shorthorn characteristics. — There are three types of Shorthorn cattle, — namely, the beef type, the dairy type and the beef and dairy type. Each type has a conformation in accordance with the purpose for which it is to be used, for here as elsewhere *form* and *function* are closely correlated. The beef type has the typical beef form. The dairy type is somewhat angular and has good ability in transforming food into milk. The beef-dairy



Courtesy Ginn and Co.

FIG. 96. — A Shorthorn cow, showing some fine dairy characteristics.

cow has a dual conformation and function. Her food is diverted into two channels; a part goes to make milk and a part goes into beef production. The beef type of Shorthorn is the largest of the beef breeds. Cows of this breed weigh 1400 to 1800 pounds, and bulls 1800 to 2200 pounds.

The Shorthorn cattle are red, white, roan and spotted. Roan cattle are popular at present. It is an excellent color, for it is more easily kept clean on show cattle than either red or white.

We should always remember, however, that color is a matter of only secondary importance.

Shorthorn cattle are good milkers, and this fact, along with the fact that they are the largest of the beef breeds, and possess a strong constitution, makes the breed extraordinarily popular.

Hereford cattle. (*a*) History. — Early Hereford history is obscure, but the following men did much in unifying and establishing the breed in England.

NAME	BORN	DIED
Benjamin Tompkins	1714	1789
Benjamin Tompkins, Jr.	1745	1815
Williams Gallier	1713	1779
John Price	1776	1843
John Hewer	1787	1873

These men lived in Hereford County, England; hence the name of the breed.

Henry Clay, in 1817, imported the first Hereford cattle into the United States. Although other importations followed, the Hereford breed did not get a good start in the United States until after 1860. To-day the breed is very popular, especially on the plains of the West. At the International Stock Show held annually at Chicago, the Shorthorn breed is in the majority; but at the Royal, held annually at Kansas City, the Hereford has a higher entry than all other breeds combined.

(*b*) Characteristics. — Hereford cattle are typical beef cattle. They are compact, close to the ground and possess the best feeding qualities. They are fairly large when mature, the cows weighing 1500 to 1800 pounds and the bulls weighing 1800 to 2100 pounds. The Hereford color is red, and the head is white with white extending over the neck, withers and underline. The feet and the switch of the tail are always white. That their milking ability is limited indicates that almost all the food they consume is used for meat production.

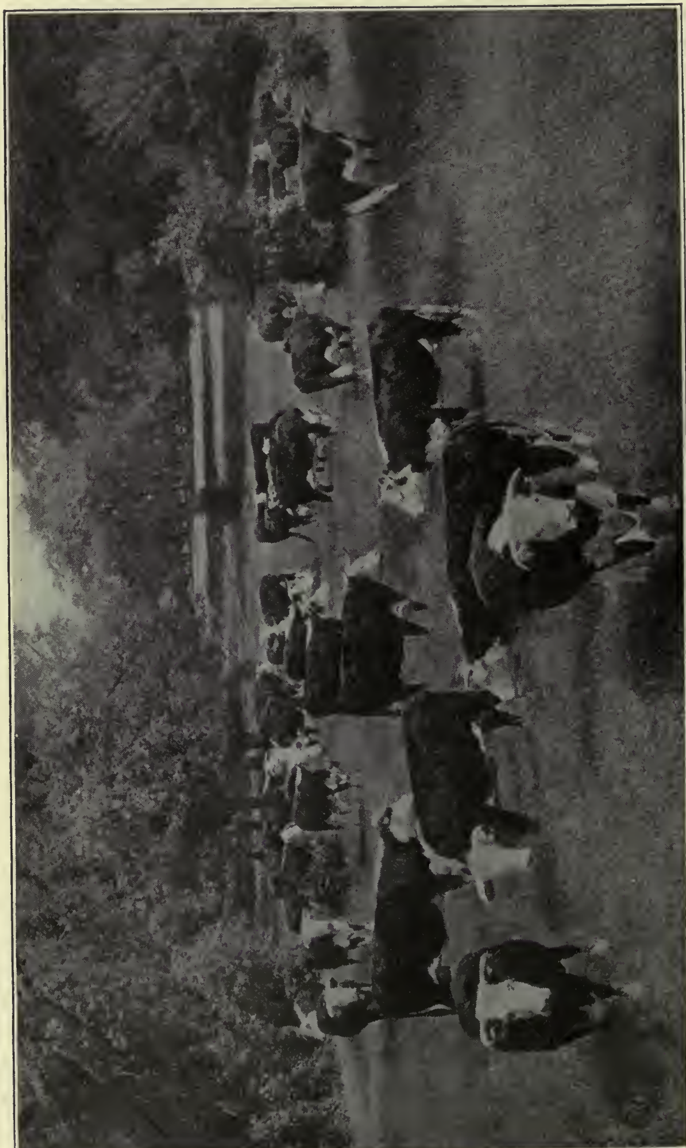


FIG. 97. — A herd of Hereford cattle. Note the uniformity of conformation, color, attitude of horns and their open pleasant countenances. They are typical beef cattle.

The Hereford cattle have the following strong points: (1) They mature early and for baby beef are unsurpassed; (2) They have an extraordinarily strong constitution; (3) They are excellent grazers and rustlers; (4) They are in the first rank in quality; (5) The fact that they produce only a limited amount of milk is a point in their favor, and (6) They are prepotent, and transmit their characteristics when crossed with other cattle.

FIG. 98. — Fine specimens of the Aberdeen Angus breed. Note the fine beef producing qualities.

The Aberdeen Angus. (*a*) History. — Kincardine County, Scotland, is the home of the Angus Cattle. The real improvement of Angus cattle was made by the following men in the early half of the 19th century.

NAME	BORN	DIED
Hugh Watkins	1789	1865
William McCombie	1805	1880
William Fullerton	1794	1841

Angus cattle were first introduced into the United States by George Grant of Victoria, Kansas, in 1873. Other importations

were made from 1875 to 1880, and after that larger numbers of Angus cattle were brought to the United States.

(*b*) Characteristics.—Angus cattle have good beef producing characteristics. They differ from the Shorthorn and Hereford cattle in being polled; their bodies also are more compact and cylindrical. They are solid black in color. Their weight ranges from 1400 to 1600 for cows and 1800 to 2200 for bulls. They sell more readily than any other breed as a butcher's beef because of their superior quality. No breed will weigh heavier for its size.

The strong features of the Angus are: (1) They dress a high percentage of dressed carcass; (2) They are superior in quality; (3) They are polled; and (4) They are adaptable to cold climatic conditions.

The Galloway cattle. (*a*) History. — The Galloway cattle originated in southwestern Scotland. Their improvement dates back into the 18th century. They were first imported into the United States about 1850, though their importance was not realized to any great extent until about 1875 to 1900.

(*b*) Galloway characteristics. — They are typical beef cattle, with long, black, wavy hair.

The long haired hides of Galloway cattle are often made into fur coats, which take the place of the coats made from buffalo hides. The Galloway cattle are adapted to severe cold weather and are very good grazers. Their hardiness is in the first rank. The breed is hornless. The shortcomings of the breed, such as flatness of ribs, late maturity and slow response to feeding, are being overcome.

Factors in economic beef production.—The most important factors in economic beef production are: (1) Type of steer; (2) Age of steer when marketed; (3) Care and management; (4) Proper feed and the use of cheap roughages; (5) Shelter; and (6) The prevention of disease.

1. *Type of steer as an item in economic beef production.* — A steer of good conformation, quality, disposition and beef tempera-

ment is of prime importance in making cheap gains. It does not pay to feed a steer of poor type.

2. *Effect of age on cost of fattening.* — The effect of age on cost of fattening is well illustrated by the following table, which is taken

Courtesy Galloway Breed Assoc.

FIG. 99. — An excellent specimen of the Galloway type. Note the black color, long curly hair and substance that stamp the breed.

from the experiments carried on at the Ottawa Experiment Station, Canada, with 153 steers in feeding trials extending over about

DAILY GAINS AND AVERAGE COST OF FATTENING STEERS OF VARIOUS AGES

	AVERAGE WEIGHT AT BEGINNING, LB.	AVERAGE DAILY GAIN, LB.	AVERAGE COST OF 100 LB. GAIN
Calves	397	1.8	$4.22
Yearlings	883	1.6	5.31
2-year-olds	1011	1.8	5.62
3-year-olds	1226	1.7	6.36

6 months. It will be noted from this feeding trial that calves made gains at about two-thirds the cost of the 3-year-old steers.

Calves born in the spring and sold when 14 to 20 months old probably make more and cheaper meat than steers held longer. This provides two summer seasons for their production and only one winter. Cheap beef must be produced in the summer months upon grass. Steers held over one winter require for each pound of gain less capital, labor and shelter than where they are kept longer.

The demand for baby beef is increasing. Well-finished calves weighing 800 to 1100 pounds are known as baby beef. These

Courtesy U. S. Department of Agriculture.

FIG. 100. — High class baby beef.

calves are 14 to 18 months old usually. Their development is forced from birth to the time they are sold. Good feed is provided, and the care and management is such that gains are most rapid. The purchasing and selling price of baby beef calves is narrower than it is for common feeders. Only good quality calves can be used for baby beef production. Spring calves are marketed to best advantage the summer or fall when they are about 18 months old.

3. *Care and management of steers is an important factor in beef production.* — Quietness is essential in the handling of live stock. Quietness of manner causes the cattle to become gentle, while brusqueness of manner causes them to lose confidence in the feeder, and become shy. Dehorned cattle do better than horned ones. They require less shed or lot space, fatten somewhat quicker, ship better, and bring slightly higher prices. Keeping salt before cattle helps in beef production. *Regularity* in time and manner of feeding helps in the fattening process.

4. *Proper feeding and the use of cheap roughages help in economic beef production.* — Grasses, old straw stacks, cheap hays and other roughages help to produce beef on a narrow margin. Henry and Morrison say,[1] "It is doubtful if any other article of universal use and necessity is continuously sold on so narrow a margin over cost, if any, as the live fattened steer." And it is the cheap feeds which help to widen the margin of profits.

Beef steers require a balanced ration if they are to make good economic gains. This is well illustrated by the following table, showing results with two-year-old steers.[2]

BALANCED AND UNBALANCED RATION FOR STEERS

Average Daily Ration	Initial Weight Lb.	Daily Gain Lb.	Feed for 100 Lb. Gain	
			Concentrates Lb.	Roughage Lb.
Unbalanced ration: 90 steers, corn, 15.2 pounds; . . . carbonaceous hay, 13.0 pounds	839	1.7	930	832
Balanced ration: 71 steers, corn, 15.2 pounds; . . . legume hay, 13.0 pounds . .	952	2.3	689	575

The daily gain on corn and carbonaceous hay was 1.7 pounds, while the daily gain on the same amount of corn and legume hay

[1] *Feeds and Feeding.*

[2] Kansas Station Bulletin No. 132.

was 2.3 pounds, or one-half pound more. It will also be noted that much more feed was required when corn and carbonaceous roughage were used.

Shelter, in the form of well-covered sheds, is helpful in beef production. Closed barns and confining stables have not proved to be superior to open sheds in beef production. Waters has well stated the condition for beef production in the following statement: "It is more important that fattening animals lie down regularly and during a large portion of the time than that they be protected from the cold. An abundance of sunshine and fresh air, a comfortable place in which to lie, and freedom from all external disturbances are ideal conditions for large and economical gains."

The prevention of disease is an important factor in beef production. (1) *Blackleg* is a common infectious disease among beef cattle, occurring usually in calves 6 to 18 months old. Lameness, high fever, loss of appetite, and tumors and swelling on one or more legs are the symptoms of the disease. Tumors may appear on the neck, thigh, breast, flank and rump, but never below the knee or hock. When tumors are cut a dark red, frothy, bad smelling liquid is discharged. The animals die in one to three days. Blackleg vaccine is a preventive of blackleg and will protect calves from the disease for about 8 to 12 months. This vaccine is injected just under the skin of the shoulder with a hypodermic syringe.

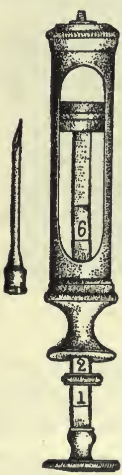


FIG. 101. — Hypodermic syringe for vaccinating.

(2) *Texas or tick fever* is caused by a small animal parasite. This disease is limited to the Southern States, although the ticks may be carried to the Northern States by cattle shipped from the South. Cattle having the disease become emaciated, and the red corpuscles are finally destroyed. The tick causing the disease multiplies rapidly, but its mode of travel is by foot only. This is a fortunate thing for, if

it could fly, cattle production in the South would probably become extinct.

The best way to combat and check the Texas fever tick is to quarantine tick infested cattle. Since the ticks cannot travel far, quarantining confines them to a given area. And since their perpetuation depends upon the fact that a part of their life cycle must be spent upon cattle, they may be successfully combated by dipping the cattle. Beaumont crude oil or a five per cent solution of any coal tar dip will destroy the tick.

(3) *Foot and mouth disease* is highly infectious and is transmitted to all cloven-footed animals. This disease is transmitted through direct contact. The symptoms of the disease are blisters in the mouth and between the toes of the feet, and a profuse slobbering from the mouth. Mayo[1] states, "Destruction of affected animals and thorough disinfection, these are the only methods that have ever been effective in dealing with the disease."

Summary. —The production of beef cattle has the advantage of maintaining the fertility of the soil, of utilizing rough lands and rough feeds, of helping to solve the labor problem, of saving transportation, and of diversifying crops. The Shorthorn, Hereford, Aberdeen Angus and Galloway cattle are the most economical producers of beef, because they provide more pounds of porterhouse, sirloin, prime of rib, round and rump cuts than any other breeds, and also because they use feeds more efficiently in putting on weight.

The more important factors in economic beef production are, type of steer, age of steer when marketed, care and management of steers, — in providing quietness, dehorning, salting and feeding regularly, — proper feeding, rational use of shelter and the prevention of cattle diseases.

It is to be hoped that the number of pounds of beef produced in the United States per capita will increase. Three things important in the maintenance of our soil fertility are the production of more grass, more legumes and more beef cattle. These also will

[1] *Diseases of Farm Animals.*

help in solving the labor problem and in making farm life more agreeable and farmers more prosperous.

QUESTIONS

1. What was the number and value per head of beef cattle in the United States, January 1, 1918?
2. What are the leading beef producing states?
3. What are the advantages of beef production?
4. Name the five most valuable cuts of a beef steer.
5. Describe the beef type.
6. What are the most popular beef breeds of your community? Why?
7. What are some of the factors aiding in economic beef production? Discuss two that are most applicable to your locality.
8. Balance a ration of 60 pounds of blue-grass and 40 pounds of white clover and compare it with the Wolff-Lehmann standard.
9. Describe the breed characteristics of Hereford and Shorthorn cattle.
10. Compare the price on foot, percentage of dressed carcass and food value of beef cattle and hogs.

PROBLEMS

1. What are some of the points which assist in producing beef on very narrow margins? Discuss the same.
2. Give a good balanced ration for winter use for a beef steer.
3. Report on the dehorning of cattle.

REFERENCES

Mumford, Beef Production.
Craig, Judging Live Stock.
Harper, Animal Husbandry for Schools.
Plumb, Types and Breeds of Farm Animals.

ADDRESSES OF BREED ASSOCIATIONS OF BREEDS OF CATTLE

These Associations will probably furnish a few copies of their publications to each school.

American Aberdeen Augus Breeders Ass'n, Chas. Gray, Sec., Chicago, Union Stock Yards.

American Hereford Cattle Breeders Ass'n, R. J. Kinzer, Kansas City, Mo.

American Shorthorn Breeders Ass'n, F. W. Harding, Chicago, Union Stock Yards.

American Galloway Breeders Ass'n, R. W. Brown, Carrollton, Mo.

Red Rolled Cattle Club of America, H. A. Martin, Gotham, Wis.

Polled Durham Breeders Ass'n, J. H. Martz, Greenville, Ohio.

CHAPTER XVIII

DAIRY CATTLE AND MILK PRODUCTION

Importance of dairying. — There were in the United States on April 16, 1910, 20,625,000 dairy cows worth $35.29 per head. On January 1, 1919, the number had increased to 23,467,000 and the price per head was $70.59. The following figures show the numbers and aggregate value of the different farm animals in the United States, January 1, 1918:

NUMBERS AND VALUE OF FARM ANIMALS (CROP REPORTER)

	NUMBERS	VALUE PER HEAD	VALUE
Horses	21,563,000	$104.28	$2,248,000,000
Beef cattle	43,546,000	40.88	1,780,000,000
Dairy cattle	23,284,000	70.59	1,643,000,000
Swine	71,374,000	19.51	1,392,000,000
Mules	4,834,000	128.74	621,000,000
Sheep	48,900,000	11.82	578,000,000

This report shows that dairy cattle in 1918 ranked fifth in numbers and third in value among the important farm animals. Some of the reasons why dairy cattle are increasing in numbers will be discussed under the next heading.

The advantages of dairying. — 1. *The first advantage of the dairy cow is that she produces more human food from a given amount of feed than any other farm animal.* This is shown by the table on the next page.[1]

From this table may be seen the order in which domestic animals utilize feed in the economic production of human food.

[1] Jordan, *The Feeding of Animals.*

Human Food Produced by Farm Animals from 100 Pounds of Digestible Feed

Animal	Marketable Product, Lb.	Edible Product, Lb.	Animal	Marketable Product, Lb.	Edible Product, Lb.
Cow (milk) . .	139.0	18.0	Poultry (eggs) .	19.6	5.1
Pig (dressed) .	25.0	15.6	Poultry (dressed)	15.6	4.2
Cow (cheese) .	14.8	9.4	Lamb (dressed) .	9.6	3.2
Calf (dressed) .	36.5	8.1	Steer (dressed) .	8.3	2.8
Cow (butter) .	6.4	5.4	Sheep (dressed) .	7.0	2.6

2. *Dairying protects the fertility of the soil.* Grain farming depletes the soil, but dairying protects the soil more than any other kind of live stock farming. This is well illustrated by the following table.

Soil Fertility Removed per Ton of Product Removed by Different Farm Products

	Fertilizing Constituents in 2000 Lb.[1]			Fertilizing Value per Ton
	Nitrogen Pounds	Phosphoric Acid Pounds	Potash Pounds	
Dent corn . . .	32.4	13.8	8.0	$ 6.85
Wheat	39.6	17.2	10.6	8.43
Timothy hay . .	19.8	6.2	27.2	5.20
Red Clover hay .	41.0	7.8	32.60	9.29
Alfalfa hay . . .	47.6	10.8	44.6	11.06
Cottonseed meal .	120.4	53.2	36.0	15.68
Animal Products				
Fat ox	46.6	31.0	3.6	$ 9.96
Fat pig	35.4	13.0	2.8	7.10
Milk	11.6	3.8	3.4	2.43
Butter	2.4	0.8	0.8	0.57

Prices of the elements of nitrogen, phosphorus and potash are figured at 18, 4.5 and 4.5 cents per pound respectively.

Dairying causes the farmer to rotate his crops, so that grain, hay crops, pasture, and legume crops are grown in regular systematic order. The plan of the farm discussed page 176 illustrates the system of crop rotation which may be practiced.

The dairyman is usually an importer of feeds. This also helps in maintaining and increasing soil fertility, for each ton of cottonseed meal, wheat bran, or alfalfa brought upon a farm introduces plant foods.

A fourth way in which dairying helps to maintain soil fertility comes from the fact that every 1000-pound dairy cow voids about 12 tons of manure annually. This manure is worth on an average $2.50 per ton. The manure is worth about $30 per year.

3. *Dairying brings constant returns.* Constant returns give comfort and contentment the year round, a highly important thing in making farming as well as any other occupation satisfactory.

4. *Dairying provides constant employment.* People who are employed one month in the year and unemployed the rest of the year are discontented during the time they are not employed. A year's work consists of 2400 to 3000 hours of work.

5. *The dairy cow is a manufacturer.* She converts large amounts of roughages into milk, which may be divided so that a few pounds of valuable butter fat remain. The following table illustrates the manufactured product:

40 lb. silage. 10 lb. alfalfa hay. 5 lb. corn. 2 lb. cottonseed meal.	25 lb. milk = 1 lb. butter fat.

This is transforming rough feeds into a finely finished product.

6. *The dairy product is always in demand.* Whole milk, skim milk, butter, cheese and ice cream are coming to have higher and higher values in the estimation of the people. These products are as good as money when presented in the market of the world.

7. *Dairying is adapted to high-priced land.* Land in Holland sells for $1200 to $2000 per acre; the land in the Island of Jersey

is likewise high priced. Around our cities land is often high priced, although not necessarily fertile, — still dairying is practiced.

Dairying, then, has many advantages. The dairy cow is the most economical producer of human food with a given amount of feed; she has a high capacity for maintaining the fertility of the soil; she brings constant returns and gives constant employment; she is a manufacturer; her product is in demand; and she brings a profit on high priced land.

The essentials of a good dairy cow. — The essentials of a good dairy cow are: (1) Size; (2) Constitution; (3) Capacity; (4) Circulation; (5) Dairy temperament; and (6) Good udder development.

1. Size is an important consideration in a dairy cow when it comes to milk production upon a commercial scale. For family use a cow weighing 800 to 900 pounds may be large enough, but for commercial purposes cows weighing 1100 and more bring better returns as the following table indicates:

RELATION OF SIZE OF COWS TO VALUE OF PRODUCT ABOVE FOOD COST
(1) Wisconsin Bulletin 226

Weight of Cows Pounds	Average Weight Pounds	No. of Cows	Lb. of Butter Fat	Value of Product	Value of Feed	Value of Product for $1.00 Feed	Value of Product above Food Cost
900 and under	847	87	366.2	$114.52	$60.32	$1.90	$54.20
900–1000	952	82	417.8	131.22	69.86	1.88	61.36
1000–1100	1071	53	447.8	142.56	76.28	1.87	66.28
1100–1200	1175	60	477.7	155.02	82.81	1.87	72.21
1200–1300	1276	31	506.2	163.52	91.51	1.79	72.01
1300–1400	1379	26	525.8	171.79	92.15	1.86	79.64
Over 1400	1556	16	566.6	184.61	96.60	1.91	88.01

From the table it will be observed that the 16 large cows produced $88.00 worth of product above food cost, while the 87 small cows produced an average of $54.20 worth of product above cost of production.

2. The second essential of a good dairy cow is constitution. Longevity is very important for it requires a few years' production to offset the cost of rearing the calf and the cost of keep. Records covering one year should not interest us as much as large yields covering several years. The economic productive period of the average cow is 5 to 6 years, but a cow with a good constitution should be profitable for 10 to 12 years. The following table illustrates constitution, longevity, and economic production.

RECORD OF JOHANNA CLOTHILDA. UNIVERSITY OF WISCONSIN COW

YEAR	MILK, LB.	BUTTER FAT, LB.	BUTTER FAT, TEST
1904–05	7,793.2	297.33	3.83
1905–06	11,681.5	430.29	3.68
1906–07	11,188.9	407.12	3.64
1907–08	13,186.2	477.96	3.62
1908–09	13,815.0	511.44	3.70
1909–10	15,565.0	578.10	3.71
1910–11	15,712.0	542.09	3.45
1911–12	12,005.0	400.40	3.34
1912–13	14,528.0	497.03	3.42
1913–14	14,350.5	486.38	3.39
1914–15	10,207.5	361.64	3.53
Totals	140,032.8	5,789.28	3.57

This cow produced more than 140,000 pounds of milk, a wonderful record (about 116 times her own weight), showing that the cow had an excellent constitution. The annual production of the average dairy cow according to the 1900 census for the United States was 3600 pounds. A cow producing 3600 pounds of milk will in ten years produce about one-fourth as much as Johanna Clothilda produced during her lifetime of 12 years of production. In order to be profitable a cow should produce at least 6000 pounds of milk and 250 pounds of butter fat. Four thousand pounds of milk testing 3.5 per cent is not enough, but 4000 pounds of milk testing 6 per cent yields 240 pounds of butter fat, a fairly good yield.

3. By capacity we mean the capacity of a dairy cow to consume large quantities of feed and her ability to transform it into the

finished product, milk. A cow of good capacity is a good feeder, and, more than that, has an extraordinary ability to digest her feed. The points which indicate capacity are a large heart and barrel girth, and a box shaped muzzle. A short ribbed, slabsided cow can consume only small quantities of feed and therefore can produce only small quantities of milk.

4. A fourth essential of a good dairy cow is good blood circulation. Good circulation is shown by large milk veins, a network of veins on the udder, a clear eye, and a plastic, soft, good quality skin. The following cuts indicate examples of good blood circulation.

The blood circulation in a good dairy cow is in the direction of the udder, while in a beef steer it is to greater extent in the direction of the valuable cuts. Large milk wells show that the cow has done heavy work at some time in the past or is doing it now, for the milk wells retain an extended size when they have done heavy work at any time. The milk veins change in accordance with the work put upon them, although as a cow grows aged they become smaller. Poor circulation is shown by small milk veins, a boardy skin, and dry, stiff hair.

5. Dairy temperament, shown by a triple wedge conformation, angularity, and a disposition to turn food into milk, is very important in a dairy cow. The beef type of cattle or dual type of cattle has not produced milk as cheaply as has the dairy type. This is shown by the following table:

Economy of Milk Production of Dairy and Beef Types

Types	Number of Animals	Average Live Weight Lb.	Pounds Dry Matter Consumed			Feed Cost of 1 Lb. Fat Cents
			Daily	Daily per 1000 lb. Live Wt.	Per lb. Fat	
Beef type	3	1240	20.8	16.7	31.3	17.5
Less beef type . .	4	945	20.4	21.0	26.4	15.1
Spare but lacking depth of body .	3	875	20.0	23.0	25.5	14.6
Dairy type . . .	12	951	21.9	23.6	21.2	12.1

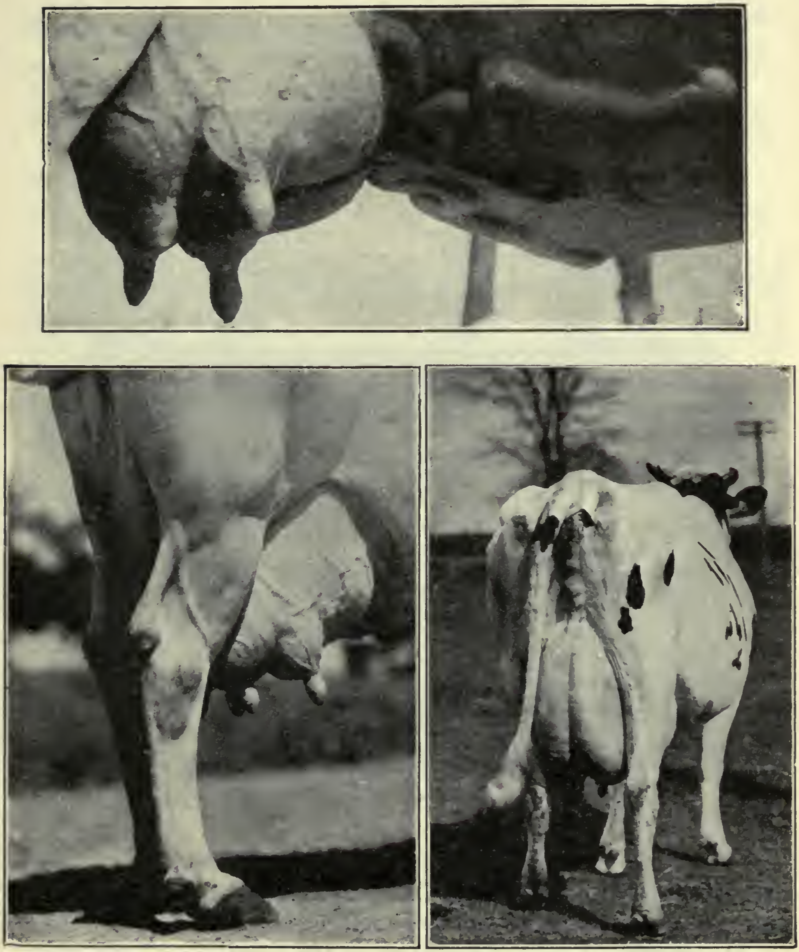


FIG. 102. — Note the large milk veins in the upper part of the figure, and the network of veins in the lower part of the figure.

The dairy type produced a pound of butter fat at a cost of 12.1 cents per pound, whereas the beef type produced an equal amount of butter fat at a cost of 17.5 cents. One reason many cattle

used for milk production do not yield more is that the cows are not of the proper type.

The contrast of the beef type and the dairy type is shown in the following picture. The form of each conforms very closely to the purpose it has to serve.

6. The sixth coördinate essential of a good dairy cow is an udder of proper *form* and *texture*. A well-formed udder is evenly

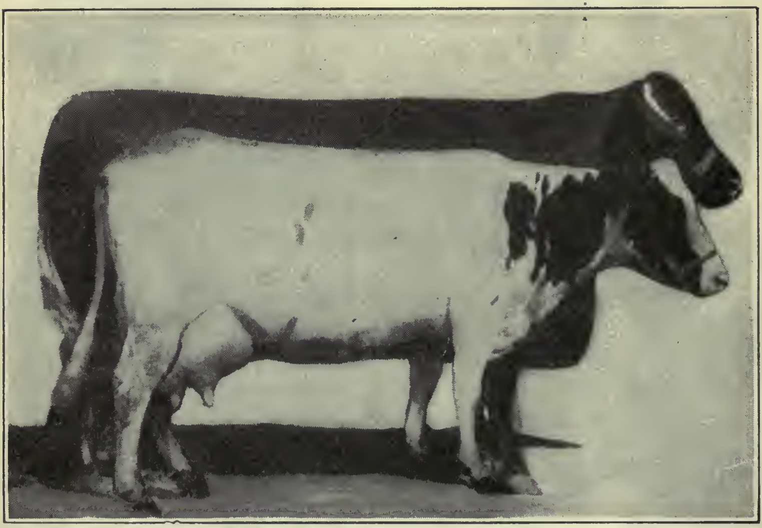


FIG. 103. — Beef and dairy type in outline. Compare their conformation and function.

quartered, extended well to the front and to the rear, and is wide and fairly deep. The teats should be of proper size, and be well placed. The floor of the udder should be level.

The texture of the udder refers to the softness and the open capacity of the udder. An udder that is fleshy, compact, and has only a small amount of interior space lacks interior milk secreting surface. An udder of good texture collapses when milked dry, while an udder of poor texture maintains the same form after milking that it had before milking. The following picture shows

a cross section of an udder. Doubling the interior openings and also their capacity would quadruple the capacity, content and working ability of the udder.

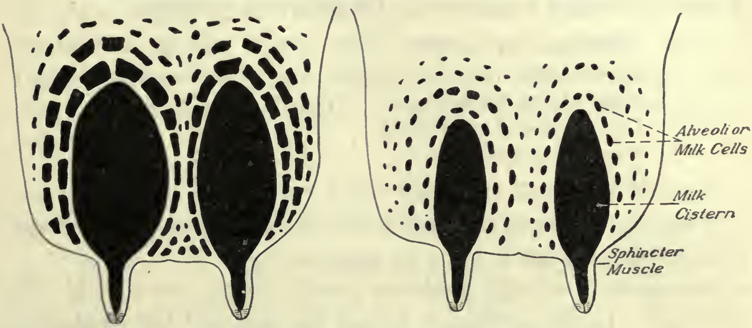


FIG. 104. — An interior longitudinal section of the udder. In the above figure the black shows the interior open-space, the white, fibrous muscular tissue. The cut to the left shows about three times as much open space as the one at the right.

Cost of keeping dairy cows and milk production. — The cost of raising dairy heifers until they are 24 months old has been found by Bennett and Cooper of Wisconsin with 117 calves to be as follows:

COST OF REARING DAIRY HEIFERS IN WISCONSIN

	COST TO ONE YEAR	COST TO TWO YEARS
Initial value of calf	$ 7.04	$ 7.04
Feed	24.67	40.83
Labor	4.45	7.81
Other costs	6.36	13.75
Gross cost	$42.52	$69.43
Credit for manure	3.00	8.00
Net cost	$39.52	$61.43

A cow during her first lactation period would have to produce an extremely large quantity of milk to pay for the cost of raising her, and for her keep during the period. But the production of milk

over a long number of years reduces the cost of milk production per year. The cost of keeping a dairy cow a year, of course, varies greatly with different years and localities. Farrington of the Wisconsin Station has given us the following estimate.[1]

Stable taxes and interest	$ 3.00
Depreciation	6.00
Value of feed per cow	30.00
Cost of milking and feeding	8.00
Sundry expenses	3.00
Total	$50.00

If we are to know whether a cow is making or losing money we must know what it costs to keep her.

The quantity of milk produced greatly affects the cost of milk produced. Large production lowers the cost, and low production increases it. A cow producing 4000 pounds of milk does not produce milk as cheaply as one yielding 8000 pounds, although it costs more to feed a heavy producer than one which produces only a small quantity. The following table is based upon the assumption that it costs $50 to keep a cow.

Cost of Milk from Cows Producing Different Amounts

Pounds of Milk per Year	Cost to Produce 100 Lb. of Milk	Cost of Producing a Quart of Milk
3,000	$1.70	3.3
4,000	1.25	2.5
5,000	1.00	2.0
6,000	.83	1.7
7,000	.71	1.3
8,000	.62	1.2
9,000	.55	1.1
10,000	.50	1.0

The dairy breeds. — The leading dairy breeds of cattle comprise the Holstein-Friesian, Jersey, Guernsey, and Ayrshire. These are the major dairy breeds; the minor dairy breeds include the

[1] Wisconsin Buttermakers' Association Report, 1911.

Brown Swiss and Dutch Belted. The first four named will be discussed.

1. **Holstein-Friesian cattle.** (*a*) History.—The Holstein breed of cattle originated in Holland, and for 2000 years has been an established breed. These cattle were first imported into the United States about 1795. Since then the breed has been widely distributed and its popularity is increasing, as the following data indicate:

Number of Registered Dairy Cattle of Different Breeds [1]

Breed	Before 1895	1895–1904	1905–1914	Total Up to 1915	Last Ten Years Compared with Previous Ten Years. Per Cent
Holstein	56,141	49,296	267,374	372,811	542
Jersey	143,519	111,782	197,300	452,610	172
Guernsey	11,029	15,661	52,450	79,141	335
Ayrshire	18,306	11,051	26,919	56,276	244

It will be noted from the last column of the table that Holstein popularity is increasing. The Holstein-Friesian cattle breed organization was formed in 1883.

(*b*) Holstein characteristics. — Holstein-Friesian cattle are the largest of the dairy breeds. Cows weigh 1100 to 1300 pounds and bulls weigh 1800 to 2500. The color of the breed is white and black, with a preference for a greater proportion of white. In form, the specimens of this breed are not quite as typical of the dairy type as are some of the other breeds. In Holland four types of Holstein cattle prevail; namely:

The typical dairy type.
The beef type.
The dairy-beef form.
The beef-dairy form.

In Holland, since $\frac{4}{5}$ of all the calves are slaughtered for veal, they produce a type of cow which is fairly efficient as a meat

[1] Eckles and Warren, *Dairy Cattle.*

producer. The birth weight of Holstein calves ranges from 85 to 100 pounds. The calves are unusually large and possess a strong constitution. The Holstein cow in Holland performs three types of work. She pulls the plow and does the heavy draft work; she produces milk for the family; and she produces meat. The fact accounts largely for the type and characteristic qualities the breed possesses. However, the low, level, fertile country of

Courtesy Holstein-Friesian Association.

FIG. 105. — A good type of Holstein bull. Note the conformation, color and size.

Holland is also responsible to a considerable extent for the physical characteristics and dairy qualities of the breed.

(*c*) Dairy characteristics. — The Holstein cow has excellent dairy qualities: (1) She produces a greater quantity of milk with a given amount of feed than cattle of any other breed. (2) The butter fat globules of the milk are comparatively small, making the milk adaptable for hospitals, infant feeding, and general household use. Milk containing small fat particles is probably more easily

digested than milk containing large fat globules. (3) Holstein milk is generally light in color. (4) The butter fat test of the Holstein is lower than it is for the other breeds. (5) Holstein milk does not cream or churn so readily as the milk of some of the other breeds on account of the small fat globules.

The farm and dairy qualities of Holstein cattle are largely the result of the rich, fertile soil of Holland, and of the fact that

Courtesy Holstein-Friesian Association of America.

FIG. 106. — Duchess Karen Venezuela. 212246.

At 5 y. 5 m. 2 d, 535.2 lb. milk, 30.623 lb. butter. Sire, Lincoln Karen, 54413 (6 A. R. O. daughters) Dam, Venezuela 3d, 136190 (1 A. R. O. daughter).

the feed of the Holstein cattle in Holland consists of roots and vegetation — very little grains and concentrates being used.

(*d*) Criticisms of the breed. — (1) The breed is superior in quantity of milk production; (2) The cattle of the breed are large, strong and vigorous and possess the best of constitutions. They produce good healthful, wholesome milk; (3) In disposition they are quiet, docile, and unexcelled; (4) They are not only good in milk production, but in veal production as well; (5) Holstein

cattle are large, and hence are adapted to milk production upon a commercial scale.

Records of Leading Holstein Cows

Name of Cow	Pounds of Milk	Pounds Butter Fat
Duchess Skylark Ormsby	27,761	1205
Finderne Pride Johanna Rue	28,403	1176
Pontiac Clothilda De Kol	25,318	1017
Finderne Holinger Fayne	24,612	1116

2. **Jersey cattle.** (*a*) History. — The Jersey breed, which is a native of the Island of Jersey, is about 500 years old. The breed has been kept pure for many years. In 1789 an act was passed forbidding the importation of any cattle into the Island of Jersey except for immediate slaughter.

The Island of Jersey is about 11 miles long and 9 miles wide and contains 39,590 acres. From 10,000 to 12,000 cattle are maintained upon the island, or about one cow to every 2.2 acres. This is a very dense cattle population, showing again that the dairy cow is an economical producer of human food.

Jersey cattle were imported into the United States about 1850, and since then have been widely distributed. The Jersey is predominant in this country as a family dairy cow, especially on city lots. They are widely distributed in France, England, Canada, and wherever milk rich in butter fat is the sole basis for the selection of the dairy cow. This, it should be stated parenthetically, is not the only consideration in the choice of a dairy cow, for the other ingredients in the milk — casein, sugar, and ash — are worth fully as much as the butter fat. The last three named ingredients in milk will receive more attention as the years go by, because they are even more indispensable in the human dietary than is butter fat.

(*b*) Jersey characteristics. — The Jersey cow is often referred to as being a typical dairy type. There are few, if any, Jerseys possessing a beef conformation. A triple wedge conformation, angularity, and a nervous temperament consistent with the high-

est milk production are salient points of the Jersey breed. Their color is most usually a fawn, although white spots are often found on the cattle of this breed.

The muzzle, the tongue, and the switch of tail are usually black. The horns are a pale amber tipped with black. The Jersey is the smallest of the major dairy breeds (Kerry cattle are the smallest), the cows weighing 750 to 900 pounds, and the bulls

Courtesy American Jersey Cattle Club.

FIG. 107. — Gamboges' Vellum Majesty, 123063. A fine Jersey bull showing the constitution, conformation and other features desirable in a Jersey bull.

weighing 1200 to 1600 pounds. Jersey cattle respond to the generous feeding that is customary in the United States and weigh on an average 100 to 150 pounds more here than they do under their native conditions on the Island of Jersey. Because of their size, Jersey cattle are better adapted to extremely hilly and rough sections than are very large dairy cows.

(*c*) Dairy characteristics. — The dairy qualities of the Jersey cattle in comparison with the other major dairy breeds are as follows:[1]

[1] Adapted from Eckles and Warren, *Dairy Farming*.

PRODUCTION OF DAIRY CATTLE IN EXPERIMENT STATION HERDS

	Number of Cows	Pounds of Milk	Per Cent Butter Fat Test	Pounds Butter Fat	Per Cent Total Solids	No. Cows Reporting on Total Solids
Jersey . . .	153	5508	5.14	283	14.9	29
Guernsey . .	17	5509	4.98	274	14.2	6
Ayrshire . .	24	6533	3.85	252	12.9	17
Holstein . .	83	8699	3.45	300	12.29	9

It may be seen from the table that the Jersey breed produces milk testing the highest in butter fat, and also containing the

FIG. 108. — A good example of Jersey type, conformation and color.

highest per cent of total solids. This is an enviable record for any breed to hold.

Jersey cattle are the most economical producers of butter fat with a given amount of feed. Their milk is yellow in color. It has been proved by Professor Eckles of the Missouri Station that the yellow color in milk is due to carotin, a part of the coloring matter in plants, and that the yellow color in milk does not affect the richness or the composition of milk.

The butter fat globules in Jersey milk are unusually large. Butter fat particles range from $\frac{1}{25000}$ to $\frac{1}{1500}$ inch in

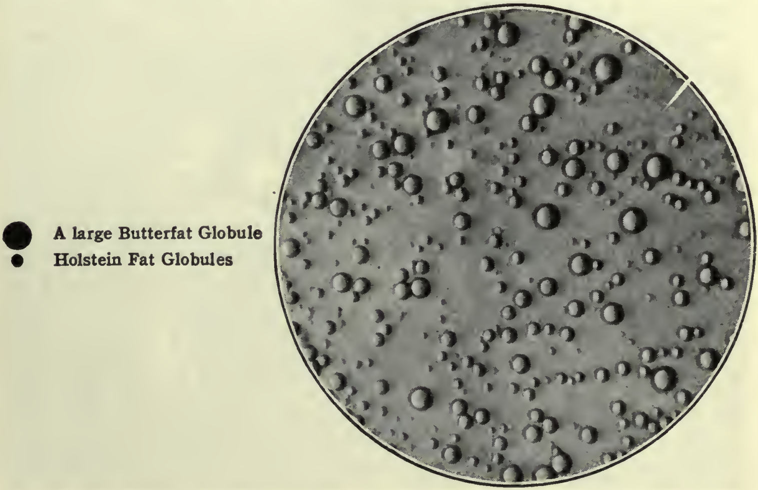


FIG. 109. — Butter fat particles range in diameter from $\frac{1}{25000}$ to $\frac{1}{5000}$ inch. The butter fat particles in the circle are magnified 400 diameters.

diameter. Jersey milk contains fat particles which are larger on an average than are those of the milk of the Holstein and Ayrshire cattle.

The large fat particles cream and churn more easily than do the small particles, making gravity skimming easier. In separating milk with separators, enough power is applied so that small particles are separated as well as large ones.

Jersey cattle are persistent milkers, and are especially adapted to economical fat production and to use as family cows.

The butter requirements for the major dairy breeds for Advanced Official Registry are as follows:

REQUIREMENTS FOR A. O. R. RECORDS

Age	Jersey, Guernsey and Holstein		Ayrshire		Brown Swiss	
	Fat	Per Cent	Fat	Per Cent	Fat	Per Cent
Two . . .	250.5	70	214.3	66	222.0	66
Three . . .	287.0	80	236.0	73	238.4	70
Four . . .	323.5	90	279.0	87	271.4	80
Five . . .	360.0	100	322.0	100	304.1	90
Six					337.0	100

The per cent indicates what amount of fat may be expected from a cow during any year of the milking period.

RECORDS OF LEADING JERSEY CATTLE

Name of Cow	Pounds Milk	Pounds Butter Fat
Sophie 19th of Hood Farm	17,557	999
Spermfield Owl's Eva	16,457	993
Eminent's Bess	18,782	962
Jacoba Irene	17,253	952

(*d*) Criticism of the breed. — The strong points of the Jersey breed are: (1) Their economical production of butter fat; (2) Their persistency in producing milk; (3) Their excellent dairy type; (4) Early maturity.

The weak points are: (1) Lack of size of the cows for large milk production upon a commercial scale; (2) Lack of vitality of calves (birth weight ranges from about 40 to 60 pounds).

3. **Guernsey cattle.** (*a*) History. — The origin and history of the Guernsey is very similar to that of the Jersey. Guernsey Island is one of the Channel Island group, and the conditions there are quite similar to those in the Jersey Island. The purity of the Guernsey is protected on the island by law.

(*b*) Guernsey characteristics. — Guernsey cattle weigh 900 to 1050 pounds, weighing 100 to 150 pounds more than the Jerseys. They are the second largest dairy breed. Their color varies, being often a light fawn with white markings. The muzzle is cream colored, the end of bone of tail is yellow, and the horn and hoofs are amber colored. The skin secretions are very yellow. The udder of the Guernsey is well formed and developed, and the

FIG. 110. — Du Luth Coronel, 52816. Produced 12603 pounds of milk, and 580 pounds of butter fat in one year, when three years old. A good specimen of the Guernsey breed.

front udder extends well to the front. Guernsey cattle have an excellent disposition, and are easily handled.

(*c*) Dairy characteristics. — The Guernsey cattle are persistent milkers, and rank high as milk producers. Their milk is very yellow, often almost objectionably so, and the fat globules are comparatively large. They compare favorably with the Jerseys in economic fat production. As is shown in the table, page 275, the breed is increasing rapidly.

(*d*) Criticism of the breed. — (1) Their size is in their favor; (2) Their milk is rich in fat and good in quantity produced; (3) Their calves are of good size and are strong. Guernsey calves weigh 70 to 75 pounds; (4) Their milk is of a rich yellow color.

The Guernsey cattle are of unusual merit and deserve special study for further production and distribution.

(*e*) The records of a few leading Guernsey cows are shown in the table.

Name	Pounds Milk	Pounds Butter Fat
Murne Cowan	24,008	1098
May Rilma	19,763	1073
Spotwood Daisy Pearl	18,602	957

4. **Ayrshire cattle.** (*a*) History. — The native home of the Ayrshire cattle is the county of Ayr in southwest Scotland. Previous to 1750 the breed was small, and the real improvement of the breed has been made since 1750.

The country of Ayr ranges in altitude from sea level on the west to about 2000 feet. Its temperature is moderate and uniform, ranging from about 30° to 65° Fahr. The prevalence of good pastures causes the breed to be filled better over the front and rear quarters and over the body than the other dairy breeds.

(*b*) Characteristics. — Ayrshire cattle are white and red in color. The cows weigh 1050 to 1100 pounds and the bulls 1400 to 1600 pounds. Ayrshire cattle carry more meat than do the Jersey and the Guernsey breeds. They are thus adapted to colder climatic conditions. The birth weight of Ayrshire calves ranges from 70 to 80 pounds, and the breed is well adapted to veal production. The horns curve outward and upward, a striking characteristic of the breed.

(*c*) Dairy characteristics. — Ayrshire cattle are noted for their uniform udders and for uniform yields in milk, though there are no records of great yields among the breed. Eckles says, "The

milk of Ayrshire cows is well adapted for cheese making on account of the small fat globules and relatively high per cent of casein, and is generally used for this purpose in their native land." The

FIG. 111. A fine specimen of the Ayrshire breed. The color is white and red. Note the fine udder. The head and horn characteristics shown above are typical of the breed.

udder development of the breed is superior, extending well to the front and back and being well held up.

RECORDS OF A FEW AYRSHIRE COWS

NAME	POUNDS MILK	POUNDS BUTTER FAT
Auchenbrain Brown Kate 4th . . .	23,022	918
Garclaugh May Mischief	25,328	897
Lily of Willowmoor	22,106	889
Auchenbrain Yellow Kate 3d	21,123	888

It is probably desirable in some localities to take up at this point the study of the Brown Swiss, Dutch Belted and the dual purpose breeds, Devon and Red Polled.

Composition of milk and its product. — Dairy cattle are kept for the milk they produce, for milk is a universal and a well-balanced food. Milk supplies all the compounds needed to nourish the body of animals.

PERCENTAGE COMPOSITION OF MILK AND SOME OTHER THINGS

	WATER	PROTEIN	CARBOHY-DRATES	FATS	ASH	CALORIFIC VALUE PER LB.
Cow's milk . . .	87	3.2	5.0	3.7	0.76	310
40 per cent cream .	73	2.4	4.5	17.6	0.4	1730
Skim-milk, gravity .	90.43	3.26	4.74	0.87	0.70	165
Skim-milk, centrifugal	90.30	3.55	5.25	0.10	0.80	160
Buttermilk . . .	90.12	4.03	4.04	1.09	0.72	160
Wheat bread, white	35.0	9.2	53.1	1.3	1.1	1200
Man's body (adult)	60.0	18.0	0.0	15.0	5.5	
Butter	12.5	1.26	0.0	82.5	2.58	3600
Cheese, full cream .	38.0	25.33	1.43	30.0	4.97	2070

Of all the dairy products whole milk is the best, although skim milk is often the cheapest food. Why so much labor should be spent in separating milk and making it into such a variety of products is more than the author can explain, for whole milk can ordinarily be placed upon the market more cheaply than it can be separated into its constituents, and the constituents marketed. Next to whole milk, cheese is the most nutritious of milk products, and it is certain that there will be more cheese factories in the future. It is likely on the other hand that creameries will not increase as they have done in the past. Cheese factories are bound to come, for only about 4 to 5 pounds of butter can be made from 100 pounds of average milk, while about 8 pounds of cheese can be made from the same. But the original whole milk with all of its ingredients is the most wholesome, the most nutritious and the best balanced of all dairy products.

Factors conducive to greater efficiency and more economic production from the dairy herd. — The price of the daily ration, the price of man labor, the qualities of the man running the dairy, the characteristics of the individual cow, crops and seasons, distance to market and the price of the product are all fundamental factors in making the dairy profitable and satisfactory. The size of this volume prohibits the discussion of these points; but they may be discussed in class. The points which we will briefly discuss are: (1) Testing the dairy cows; (2) Use of a good sire; (3) Raising calves on skim-milk; (4) Growing diversified crops; (5) Feeding properly; (6) Having cows freshen in the fall; (7) Kindness and gentleness; (8) Preventing and combating disease; (9) Proper care and management of the herd.

FIG. 112. — Dr. S. M. Babcock, the inventor of the Babcock Test, which aids the dairyman to determine whether a cow is producing butter fat economically.

1. *Testing dairy cows* is an important factor in putting the herd upon a substantial foundation. In testing cattle, the pounds of milk produced by each cow and the butter fat test of each cow are carefully recorded and kept. By this means the profitableness of each cow may be easily determined, a very important point in putting the dairy on a sound financial basis. The testing of cows is usually done under the direction of cow testing associations. In cow testing associations the milk is usually weighed and tested twice a month by a graduate of an agricultural college. The owner of the herd weighs the milk produced by each cow, morning and night at all other times as long as the test is on.

Henry and Morrison in *Feeds and Feeding* say:

"The improvement wrought by cow testing associations is marvelous. In Denmark, largely due to their work, the average annual yield of butter per cow has increased from 112 pounds in 1884 to 224 pounds in 1908. In ten years one association in Sweden increased the annual production of butter fat 109 pounds per cow."

The Babcock Test, the milk scales and keeping an account of the cows put dairying upon a substantial basis. Dr. S. M. Babcock, the inventor of the Babcock Test, did an untold service for mankind in the discovery and invention of this important test.

The real value of testing cows is that one is enabled to determine which cows are profitable and which ones are not. Thus the poor ones may be eliminated from the herd. Some other things which may be learned from a cow tester are: (1) How to produce clean milk; (2) How to feed a balanced ration; (3) The price and feeding value of the daily ration; (4) How to prevent and eradicate disease, etc.

Circular No. 102, Illinois Experiment Station, gives the following important data, which show the result of a good deal of work and indicate good and poor producers in 24 herds with 221 cows.

The table on page 289 deserves study. Where were the profitable and unprofitable cows and herds?

2. *The use of a good sire.* — A second important factor in the improvement of the herd and in producing milk is the use of a good sire. The sire is often spoken of as being half of the herd; but that he is more than half of the herd is easily seen when a sire that transmits low milk producing ability is used. The herd may then soon terminate. A fine example of the use of a good dairy sire is given on page 199. From the available data on the selection of a good sire there is only one sure way to select him, and that by the daughters which have proved themselves to be producers superior to their dams. Sires are often selected by their pedigree. Either of these ways excels the method of purchasing them by color alone, — the color red has often caused herdsmen to buy an animal which possessed no other good qualities.

AVERAGE PRODUCTION OF THE BEST AND THE POOREST COW IN 24 ILLINOIS HERDS

HERD	NO. COWS IN HERD	POUNDS MILK			PER CENT FAT			POUNDS BUTTER FAT		
		Average	Best	Poorest	Average	Best	Poorest	Average	Best	Poorest
1	11	5753	6099	4391	4.54	5.17	3.91	262	315	172
2	8	7376	8739	4928	3.19	3.81	3.92	268	333	193
3	5	8057	9454	6719	3.42	3.40	3.27	276	324	221
4	11	6220	7445	4191	3.89	4.82	3.83	242	359	157
6	20	7873	9067	5796	3.62	4.41	3.65	285	399	212
7	10	4525	5507	3412	3.76	4.70	3.78	170	264	129
8	10	4486	6647	2691	4.29	3.09	3.61	193	263	97
10	13	5431	7291	3847	4.18	4.31	4.38	227	315	168
11	9	5969	6531	5552	3.43	3.78	3.01	205	247	168
12	13	4504	6429	2090	3.89	3.80	4.83	175	248	101
15	12	5128	6289	3491	4.03	4.74	3.01	207	299	135
16	9	4608	5293	3752	3.98	4.49	3.99	184	238	150
17	7	4355	6115	3710	3.96	3.31	3.33	173	203	124
19	19	5410	6413	4530	4.11	4.57	3.49	243	293	158
20	15	6106	7530	2980	3.84	3.93	4.56	235	296	136
21	15	5971	8882	4025	4.06	3.75	3.55	243	333	143
23	25	3314	4337	1846	4.28	4.96	4.24	142	216	78
24	9	5921	6911	3478	5.91	6.91	4.64	350	477	161
Average		5616	6994	3962	4.03	4.55	3.83	226	301	150

3. *Raising calves on skim-milk.* — The cost of raising calves is one of the greatest drawbacks to the dairy industry. It is for this reason that many calves are sold for veal. That skim-milk calves do as well as calves fed whole milk is well substantiated by experimental data. This is shown in the following table taken from the Kansas Station, Bulletin 126.

SKIM-MILK VS. WHOLE MILK FOR CALVES

HOW FED	BEFORE WEANING			210 DAYS IN FEED LOT		
	Number Calves	Length in Time. Days	Average Daily Gain. Lb.	Feed Cost 100 Lb. Gain	Average Daily Gain. Lb.	Concentrates 100 Lb. Gain. Lb.
Skim-milk . . .	10	154	1.5	$2.26	2.1	439
Whole milk .	10	154	1.9	7.06	1.9	470
Running with dams	22	140	1.8	4.41	2.0	475

It may be noted that the skim-milk calves did not do quite so well during the time before weaning, but that after weaning they gained more rapidly and with a less amount of feed. It may also be noted that the cost per 100 pounds gain for the skim-milk calf was $2.26 and that it cost $7.06 to get an equal gain upon the whole milk calf. Where skim-milk is fed to calves a proper supplement should be fed, not alone for its food value but also to provide bulk to the ration.

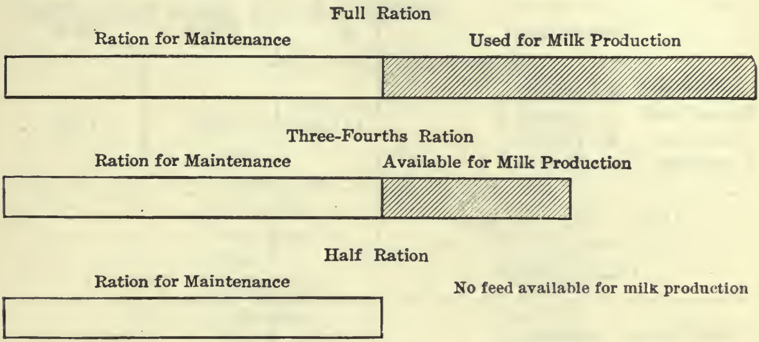
4. *Growing diversified crops.* — A variety of crops is a fourth important item in reducing the cost of milk production. Some corn, wheat and oats are grown on a dairy farm; these crops are well reënforced by such legume crops as alfalfa, red clover, cowpeas and soy beans. A part of the farm is left in pasture. This solves the labor problem to some extent by distributing farm labor. At the same time a proper balance of legume crops and the cereals helps in maintaining the fertility of the soil and in balancing the ration. The wheat crop may be sold directly as a grain crop. It has been exemplified that dairy farming combined with that system of farming where some grain crops are sold is most profitable.

5. *Feeding properly.* — Feeding well and providing a balanced ration are very important factors in making the dairy pay.

(*a*) Feeding well. — The average dairy cow utilizes 50 to 60 per cent of her feed for maintenance, and 40 to 50 per cent for production. It is immediately evident that feeding a cow for maintenance is a positive liability; nor is it profitable to feed her a little more than is required for maintenance, for about 75 to 90 per cent of the milk produced by the average cow simply goes to pay for the feed for maintenance, labor, etc. The real profit comes in getting the maximum yield. This requires a full ration. This is well illustrated by the graph on the opposite page taken from Eckles, *Dairy Cattle and Milk Production.*

The diagram clearly shows that a full ration is much more profitable than a smaller ration, for the profit in feeding comes not from the feeding of the first fractional part of the ration (say

90 per cent), but from the last fractional part of the ration. Feeding well is one of the fundamental factors in making the dairy pay.



The above graph represents the way feed is used by a dairy cow. The first portion of the feed is used for maintenance. It is an absolute waste as far as production is concerned.

A three-fourths ration may pay if the cow is a heavy producer, but in most cases the milk produced from a cow fed a three-fourths ration would not offset the cost of production.

A full ration pays best, for it is the last 5 or 10 pounds of milk that yield the real profits. All the rest of the milk pays for the feed and the labor.

(*b*) Feeding a balanced ration. — Many dairy men feed rations which are rich in carbohydrate material, and lacking in protein material. All cereal feeds require a nitrogenous supplement. The data on page 292 illustrate the point very well.[1]

Lot 2 in producing an average of 20.5 pounds of milk daily was probably just balancing accounts; but Lot 1 in producing 30.1 pounds of milk daily was putting the extra 10 pounds on the side of the profits. It pays to feed a balanced ration. At 10 cents a quart Lot No. 1 was producing at the rate of $1.50 worth of milk daily per cow, and Lot No. 2 was producing at the rate of $1.00 worth of milk per cow. The profit came in producing the last 50 cents' worth of milk.

A well-balanced ration should include not only a proper proportion of protein and carbonaceous feeds, but the required mineral

[1] Illinois Station Bulletin No 159.

CORN REQUIRES SUPPLEMENT FOR FEEDING DAIRY COWS

Lot 1. 10 Cows 131 Days	N. R.	Average Daily Yield	
Balanced Ration		Milk lb.	Fat lb.
Ground corn 3.3 pounds Gluten feed 4.7 pounds Clover hay 8.0 pounds Corn silage 30.0 pounds	1 : 6.0	30.1	0.96
Lot 2. 10 Cows 131 Days			
Unbalanced Ration			
Ground corn 8 pounds Timothy hay 5 pounds Clover hay 3 pounds Corn silage 30 pounds	1 : 11.0	20.5	0.69

ingredients as well — since the ash ingredients of milk contain a high percentage of lime and phosphorus and it is important that they be supplied. While wheat bran is an excellent feed for milk production, it is better to feed some alfalfa hay with the bran, for it balances the lime and phosphorus content of the ration, which is very essential for maximum milk production. The mineral content of 1000 pounds of bran and alfalfa hay follows:

LIME AND PHOSPHORUS IN 1000 POUNDS OF BRAN AND ALFALFA

	Lime	Phosphorus
	Pounds	Pounds
Bran	0.9	29.5
Alfalfa hay	19.5	5.4

From Henry and Morrison, *Feeds and Feeding*, Table VI, Appendix.

All cereals have a low lime content but high phosphorus content; the legumes are just the reverse. And the ash ingredients as well as the protein ingredients in a feed may be supplied by feeding part cereals and part legumes.

SOME GOOD DAIRY RATIONS

Corn silage	30 pounds.
Alfalfa hay	10 pounds.
Corn	6 pounds.
Wheat bran	2 pounds.
Corn silage	25 pounds.
Red clover hay	10 pounds.
Corn	5 pounds.
Wheat bran	4 pounds.
Corn silage	25 pounds.
Alfalfa hay	20 pounds.
Corn	5 pounds.
Wheat bran	4 pounds.
Blue-grass	60 pounds.
White clover	40 pounds.

It will be well to balance a few of these feeds and compare them with the Wolff-Lehmann Standards.

6. *Cow freshening in the fall.* — Milk production is cheapened by having cows freshen in the fall, for 25 to 35 pounds more butter fat or 600 to 800 pounds more milk is produced. This is about $\frac{1}{6}$ of the production of the average cow; thus we see that about $16\frac{2}{3}$ per cent greater production may be expected from cows freshening in the fall. When whole milk is sold it may be more convenient and desirable for the cows to freshen at different times of the year, for then the milk production is more uniform.

7. *Kindness, gentleness* and *quietness* should be observed in handling dairy cows. Regularity in feeding, milking and general order of things should be observed. Dairy cows are generally of a nervous temperament and quietness aids in getting the largest milk flow. A barking dog and a noisy attendant are a drawback in getting the best returns. Babcock, the inventor of the Babcock Test, says,[1]

[1] Wisconsin Report, 1889.

"It is my opinion that kind treatment and pleasant surroundings will have a greater influence upon the quality of milk than the kind of food, provided the ration contains sufficient nutriment for the maintenance of the animal."

Kindness is so important in handling dairy cattle that W. D. Hoard, Editor of *Hoards' Dairyman* and formerly governor of the state of Wisconsin, has a placard in his dairy barn at Fort Atkinson, Wisconsin, which reads: "The rule to be observed in this stable at all times toward cattle, young and old, is that of patience and kindness. A man's usefulness in a herd ceases at once when he loses his temper and bestows rough usage. Men must be patient. Cattle are not reasoning human beings. Remember this is the home of mothers. Treat each cow as a mother should be treated. The giving of milk is a function of motherhood; rough treatment lessens the flow. That injures me as well as the cow. Always keep these ideas in mind in dealing with my cattle."

8. *Preventing and combating diseases of cattle.* — (*a*) Tuberculosis is one of the most dangerous disease enemies of the dairy cow, and the consumer of dairy products, for the disease is communicable from cattle to man. The disease is very subtle and treacherous in getting entrance into the human body, and makes its substantial progress to the destruction of its victim before he is aware that it is present. This fact warrants the enforcement of the strictest legislation against this disease both in man and beast.

It is impossible to know that an animal has the disease by external examination. But by the "tuberculin test" the disease can be detected in upward of 95 per cent of all cases. This test is made by taking the temperature of the animal at 2-hour intervals from 2 to 8 o'clock on the day preceding the injection of the tuberculin. At 6 o'clock the next morning the tuberculin is injected under the skin of the shoulder, and the temperature of the cow is again taken at 2-hour intervals until four or five readings have been made. If there is a rise of $1\frac{1}{2}$ to 2 degrees of temperature, the cow is known as a reactor and has tuberculosis.

The normal temperature of cattle is about 102° to 103° Fahr. All affected cattle should be killed and burned. The disease may be prevented to a large extent by feeding well and keeping up the vigor of the cattle, and by building barns that are well lighted and ventilated. Cleanliness of stables also helps to overcome and prevent the disease.

(*b*) Milk fever. — Milk fever does not occur with the first and rarely with the second calving, but high producing cows may get the disease with the third calf or thereafter. The disease usually occurs within 24 hours after calving. A sure symptom is the position the cow assumes, as is shown in the following figure.

The air treatment first used by Anderson of Denmark is almost a sure cure for all cases. Air is pumped into the udder with a bicycle air pump or a milk fever outfit. The air pumped into the udder is left and held in the udder for 18 hours by wrapping a tape around the teat. If the inflammation does not leave

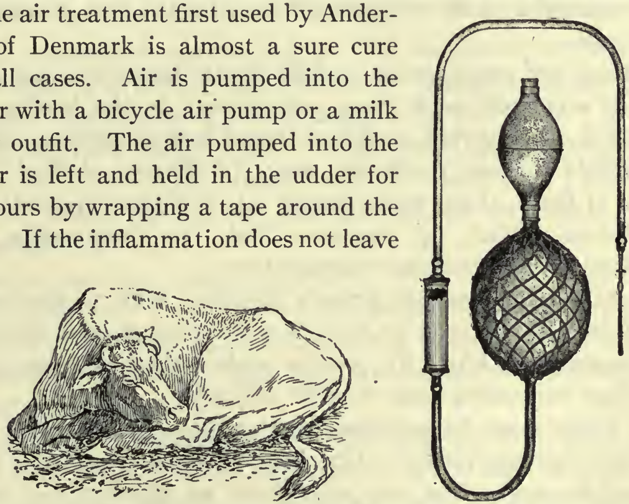


FIG. 113. — Cow with milk fever, showing the characteristic position, and the apparatus used for injecting air into the udder.

in 15 to 18 hours, the tape should be unwrapped and a second air treatment should be given. Where the milk fever is in an acute form the cow usually dies within 24 hours if treatment is not given.

(*c*) Garget. — Garget is due to a swelling and inflamed condition of the udder. The cow suffers pain because of the weight of the swollen udder. A blanket should be extended around the body

to hold the udder up. After the udder has been thoroughly rubbed a hot water bath should be applied. Give the cow 1 to $1\frac{1}{2}$ pounds Epsom salts, keep her body in the most favorable condition, provide comfort and a limited amount of rough feed (bran being an excellent feed) and plenty of cold water. Ice kept around the udder is also helpful in curing garget.

(*d*) Scours in calves. — Scours is caused by overfeeding, and the best remedy is to reduce the feed $\frac{1}{2}$ or more for a short time until normal conditions are restored. Three ounces of castor oil in a pint of milk may be given to advantage. In severe attacks $\frac{1}{2}$ ounce of formalin in $15\frac{1}{2}$ ounces of water may be prepared, and one teaspoonful of the solution given with each pint of milk fed to the calf.

9. *Care and management.* — This is an important factor in securing economic yields from dairy cows. In the feeding and housing of cattle, spring conditions should be approached as nearly as possible. These conditions are: (1) Plenty of feed; (2) Plenty of fresh, clean, tepid water; (3) Sufficient exercise; (4) A balanced ration; (5) Succulent feed; (6) Comfortable surroundings; (7) A moderate temperature.

(1) As long as pasture grass is plentiful, milk production is abundant. But as soon as there is a shortage of grass the milk flow decreases rapidly. To provide against short pastures, summer silage and soiling crops may be utilized.

(2) Water must be provided in abundance if the dairy cow is to give the best results. The water should be clean and pure and not too cold. The cow must drink an abundance of water if she is to give a great quantity of milk, for milk is 87 per cent water.

(3) Exercise is also essential for best results. Exercise causes all the organs of the body to perform their functions more efficiently. The circulatory, digestive, respiratory and milk producing organs must be at their highest working and producing capacity.

(4) Balanced and succulent ration. — Since a balanced ration has already been discussed we shall dismiss that subject, but

briefly discuss a succulent ration. A succulent ration is like the green grass, — in composition and in palatability. Silage is such a winter feed. In fact silage, blue-grass, the dairy cow's body, and milk have a somewhat similar composition.

PERCENTAGE COMPOSITION

	WATER	PROTEIN	CARBOHYDRATES	FAT	N. R.
Dairy cow body	54.0	17.8	0.0	23.0	1 : 1.2
Milk	87.0	3.2	8.7	3.7	1 : 5.3
Blue-grass	68.4	3.1	9.6	0.6	1 : 7.0
Silage	73.7	1.1	15.0	0.7	1 : 15.1

(5) Comfortable surroundings. — The stable should be roomy, well lighted, dry, and well ventilated. Sunlight should be admitted. Quietness also adds comfort to the dairy cow.

(6) Agreeable temperature. — A moderate, uniform temperature helps to bring the best results with the dairy cow. Extremely cold or warm, dry or wet weather reduces the ability of the dairy cow.

To summarize, spring conditions produce the best results because there are provided the best conditions for milk production which are, plenty of feed, plenty of fresh water, sufficient exercise, a balanced ration, succulent feed, comfortable surroundings and a moderate temperature.

Summary. — Dairying is one of the most important farm operations, and its importance is increasing from year to year. The advantages of dairying are many and substantial, for the dairy cow is the most economical of all farm animals in human food production. She tends to maintain the fertility of the soil, utilizes waste feeds and provides constant labor and a constant income. She and the hen alone are adapted to high priced land. A dairy cow for commercial purposes must possess the essentials of: (1) Size; (2) Constitution; (3) Capacity; (4) Good blood circulation; (5) The proper dairy temperament; and (6) A good

udder in form and texture. The major dairy breeds are the Holstein-Friesian, Jersey, Guernsey and Ayrshire. Each breed has its breed characteristics, and is adapted to specific conditions and purposes. The quality of milk produced by each breed is suited to a definite purpose and has marked advantages.

The factors of economic milk production are: (1) Testing the cows and thereby selecting and eliminating the boarder cows. (2) The use of a good sire; (3) Raising calves on skim-milk and thereby reducing the cost of production; (4) Growing diversified crops, and thereby maintaining the fertility of the soil, and raising a balanced ration; (5) Feeding properly; (6) Having cows freshen in the fall and thus increase the milk yield about $16\frac{2}{3}$ per cent; (7) Kindness and regularity; (8) Preventing and combating disease; and (9) Proper care and management,— these are among the important considerations in making dairying satisfactory to the dairyman and to the consumer of dairy products.

QUESTIONS

1. Compare the numbers, value per head and total value of dairy cattle with other live stock of the United States.
2. Name the advantages of dairying.
3. Give two good reasons why dairying may be practiced in regions where the land is high priced.
4. What are the essentials of a dairy cow?
5. Describe the dairy type.
6. State the advantages of a dual purpose cow.
7. What is the composition of milk? Compare milk in composition and food value with the potato.
8. Why are cheese factories destined to become more numerous?
9. Name the factors essential in making dairying more economical.

PROBLEMS FOR REPORT

1. Discuss the advantages of large cows over smaller ones for commercial milk production.
2. From data secured from a dairyman, and other sources, estimate the cost of keeping a cow at the present time for one year.

3. As a class take a census of the number and breeds of dairy cows in the town or in the school district.

4. Compare the cost and food value of milk with five other foods.

5. Report on the history of the Babcock Tester, and how to make the Babcock Test.

REFERENCES

Eckles, Dairy Cattle and Milk Production.
Eckles and Warren, Dairy Farming.
Wing, Milk and Its Products.
Bailey's Cyclopedia, Vol. III.

ADDRESSES OF DAIRY CATTLE BREED ASSOCIATIONS

These Associations will probably furnish a few copies of their publications to each school.

The American Jersey Cattle Club, R. M. Gow., Sec., New York, 324 West 23d St.
The Holstein Friesian Ass'n of America, F. L. Houghton, Brattleboro, Vt.
The American Guernsey Cattle Club, Wm. H. Caldwell, Peterboro, N. H.
Ayrshire Breeders Ass'n, C. M. Winslow, Brandon, Vt.
Dutch Belted Cattle Ass'n of America, E. J. Kirby, Covert, Mich.
Brown Swiss Cattle Breeders Ass'n, Ira Inman, Beloit, Wis.

CHAPTER XIX

SWINE PRODUCTION

Importance. — The corn producing states produce most of the swine, as the following map shows. The map is taken from the 1910 census report.

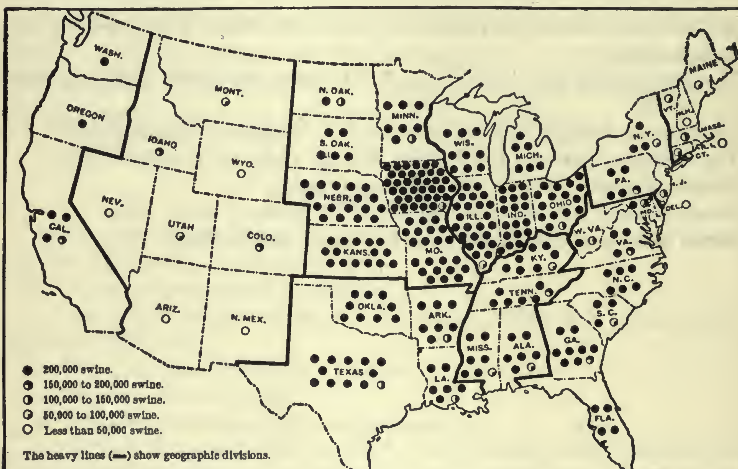


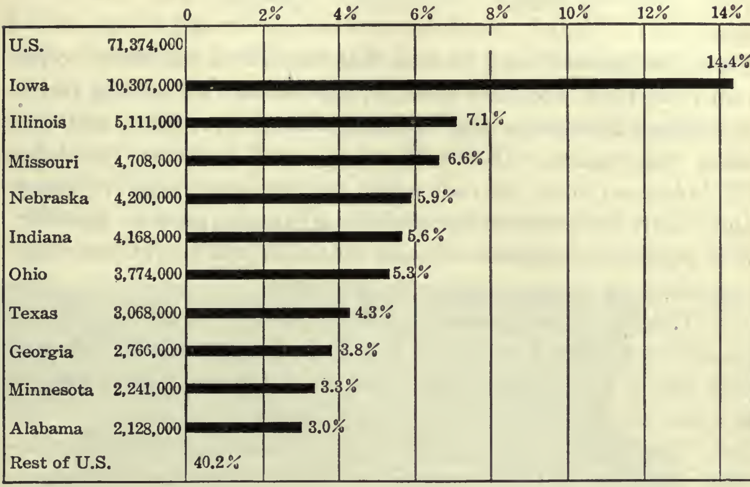
FIG. 114. — Distribution of swine production.

The total number of swine in 1910 was 58,185,000. Iowa, Illinois and Missouri had 7,500,000, 4,686,000, and 4,438,000 respectively. Indiana, Nebraska, Ohio and Kansas each had over 3,000,000 hogs. On January 1, 1919, there were 75,587,000 hogs in the United States.

The number of swine for the ten leading hog states is shown by

the following figures and graph taken from the 1917 United States Yearbook of Agriculture.

THE LEADING SWINE PRODUCING STATES



Advantages of pork production. — There are several advantages in pork production:

1. Hogs multiply rapidly. In fact they multiply more rapidly than any other farm animal. Horses, cattle, and sheep may increase 50 to 150 per cent, but swine increase 1000 to 1500 per cent in a year. If swine reproduced with as few numbers as do sheep, it would be much more difficult to produce pork economically.

2. It requires less feed to produce a hundred pounds of pork than it does to produce a hundred pounds of other kinds of meat. It requires 1000 to 1100 pounds of corn to produce 100 pounds of beef; 800 to 900 pounds of corn or its equivalent to produce 100 pounds of mutton or poultry; but it takes only 500 to 600 pounds of corn to produce 100 pounds of pork.

3. Swine dress out a higher per cent of dressed carcass than any other farm animal. The comparison for different animals is as follows:

Animal	Per Cent Dressed Carcass
Swine	70–82
Steers	60–66
Sheep	50–55

From the figures it may be seen that hogs dress out about 50 per cent more than sheep and about 25 per cent more than beef cattle.

4. Hogs consume a large quantity of waste products, and thus make cheap gains. Skim milk, whey, small potatoes, the grains left in harvest fields, the corn which the beef steers failed to digest, and the kitchen refuse are turned into a valuable product by swine. It is in the consumption of waste materials and by-products that hogs show up best as profit making animals.

5. Hogs are manufacturers. It is through them that we can market raw feeding materials in a distant city. Instead of shipping 500 or 600 pounds of corn, one may ship 100 pounds of pork, or a less number of pounds of dressed pork.

6. The fertility of the soil may be maintained in pork production, provided the feeds conducive to pork production are produced at the lowest cost and by proper farm management. Forage crops, such as rape, clover, alfalfa, blue-grass, oats, peas and beans, help in economic pork production and tend to maintain soil fertility.

7. The outlay of money in buildings and fences and money invested in the hogs themselves is not so great as it is in some other lines of live stock farming.

8. Swine mature rapidly. It requires much more time to put cattle and horses on the market than swine. This is an important advantage for pork production, for it means less risk. Money is not tied up so long, and the labor is probably less.

Types of swine. — Type is shown by the conformation in the mature form and condition. While several breeds may be included in the same type, they may differ in color, shape of head, or attitude of ears. The two types of swine are the *lard* and the *bacon* type. Breeds of swine that are short legged, broad, heavily

fleshed belong to the lard type. The Poland China, Duroc Jersey, Chester White and Berkshire belong to this type. They are sometimes called the American type of pig, and are found in their best form in the corn belt. They dress 75 to 85 per cent. The bacon type of pig is long, narrow, and thinly fleshed. The Yorkshire, Tamworth and Hampshire are the most important breeds of this type. The bacon type dresses about 70 to 75 per cent. The bacon type is of British origin. The grasses, dairy products and the demands of England for breakfast bacon are the main causes for this type of swine.

Breeds of swine. — 1 *The Poland China* breed of hogs originated in Ohio between 1820 and 1840, and it is claimed that

Courtesy Philip Hale Pub. Co.

FIG. 115. — A fine pair of Poland China hogs. Property of G. M. Curnutt, Montserrat, Mo.

the blood lines of the breed have been kept pure since 1845. The Poland China is a typical lard hog, and a general favorite

in the corn belt. The Poland type varies somewhat in color and size. There are spotted Poland Chinas, but the black type with white markings is more common. The ears are erect, breaking at the upper third. Lopped ears are objectionable. The breed's strong points are early maturity, high capacity for dressed carcass, and a high ability to turn corn into pork. The weak

FIG. 116. A Duroc Jersey sow, showing a well-arched strong back, and a straight underline. The color is cherry red.

points of the breed are lack of prolificacy, and the high per cent of fat in the meat. For crossing upon swine that lack meat producing ability the Poland China is unexcelled, and much of the common stock of swine might be improved by the judicious use of this breed.

2. *The Duroc Jersey* originated in New York and New Jersey. There was a breed of swine in New Jersey by the name of Jersey Reds; and a breed of swine in New York by the name of Durocs.

These two breeds were united officially in 1883. The Duroc Jersey is a typical lard type, and meets the demands of the feeders and packers of the corn belt. Duroc Jerseys are preferably cherry red, but may be slightly lighter. Their ears point forward and slightly outward. Large ears are objectionable. Early maturity, prolificacy and good fattening and grazing qualities are the strong points of the breed.

3. *The Berkshire breed* originated in Berkshire County, England, about 1775 to 1800. They were imported into the United

Courtesy U. S. Dept. of Agriculture.

FIG. 117. A Berkshire sow. Note the fine arched back and good underline. The color is black with six white tips. The ears are erect.

States in 1823, and are now widely distributed. Berkshire swine are black, with six white points, namely, feet, nose and tip of tail. Their ears are erect, slanting slightly toward the front. They are of the lard type, and rank in the first class in their ability to put on pork economically. The strong points of the breed are adaptability to various climatic conditions, good grazing qualities, prolificacy and meat which is well in-

terlaid with lean. As a feeder and fattener the Berkshire is unsurpassed.

4. *Chester White swine* originated in Pennsylvania. These hogs are pure white, as the name implies, and are among the largest breeds of swine. The head is almost straight and the ears droop forward. The breed is noticeably prolific, producing on an average 8.96 pigs per litter as against 8.22 for the Berkshire and

FIG. 118. — A specimen of the Hampshire breed. Note the bacon type conformation. Color is black with a white bell encircling the body including fore legs. White extending over more than $\frac{1}{4}$ length of the body is objectionable.

7.45 for the Poland China. These figures are averages of 2085 litters. As feeders they are also in the first rank, and as a breed belong to the lard type.

5. The bacon breeds comprise the Large Yorkshire, the Tamworth and the Hampshire. *The Yorkshire* are raised in England and Denmark. The general features of the breed are like the Hampshire. *The Yorkshire* breed furnishes almost all the

"Wiltshire sides," which consist of the whole side of the hog less the head and feet. Denmark in a coöperative way furnishes England with "Wiltshire sides." All members of the association pledge themselves to deliver to the packing houses hogs weighing 150 to 200 pounds live weight. A study of the Danish hog industry is well worth while to all persons interested in community improvement of live stock.

6. *The Hampshire hogs* may be traced back to England. They have the qualities shown in the picture on the opposite page. They are black, with a white belt. In prolificacy and fineness of meat in grain and distribution of lean, they are in the first rank.

7. *The Tamworth* is of English origin and is a typical bacon type. The hair is golden red, on a flesh colored skin free from black. Their meat carries a high proportion of lean to fat. The Tamworth is a popular bacon breed.

Factors in economic pork production. — The important factors in economic pork production are: (1) Improving the herd by breeding; (2) The use of forage crops; (3) Producing and raising hogs at the right season of the year; (4) Fattening well before selling; (5) A knowledge of the cost of producing hogs; (6) Properly balancing the ration and feeding the hogs; (7) Proper care and management; (8) Keeping out disease.

1. *The first factor in producing swine economically is to improve the herd.* The picture on the next page shows what improvement can be wrought even in one generation.

2. *On the use of forage crops* in economic pork production the United States Department of Agriculture has given out the following valuable data:

> One bushel of corn fed alone will produce 10 lb. of pork.
> One bushel of corn plus blue-grass will produce 12 lb. of pork.
> One bushel of corn plus clover will produce 18 lb. of pork.
> One bushel of corn plus rape will produce 20 lb. of pork.

From these data we may see the value of forage crops in pork production, for they almost double the pork produced with a given amount of corn.

3. *The time of year* when pigs are farrowed bears an important relation to economic pork production. The conditions of spring, summer and fall seasons are conducive to cheap pork production. The forage crops, pastures, an agreeable temperature and a good condition of swine due to exercise and good weather make for cheap, economic gains. If two litters of pigs are to be raised, they should be farrowed about March and August or September.

The pure bred dam

A daughter The sire

FIG. 119. — How breeding improves hogs. Note how the daughter resembles her mother.

The spring litter has the advantage of forage crops, and the fall litter may have the advantage of consuming cheaper corn.

4. *Larger litters* are essential to economical pork production. Sows should raise not less than 5 to 8 pigs per litter; and a little care during farrowing time and the following few weeks may often save from 15 to 30 per cent of the pigs. See the picture on pages 201 and 202.

Marketing hogs a little heavier than is ordinarily done may

bring good profits. The average weight of hogs slaughtered at packing houses for 1907 was 223 pounds, for 1917, 211 pounds, and for the three years preceding, 219 pounds. It is believed by the best authorities on swine production that hogs can ordinarily be fed with profit up to 250 or 275 pounds. Many hogs are marketed unfinished and too light.

5. *A knowledge of the cost of producing swine, and stabilization of prices paid for hogs are important factors in economic pork production.* Let us submit for study (1) the findings of the

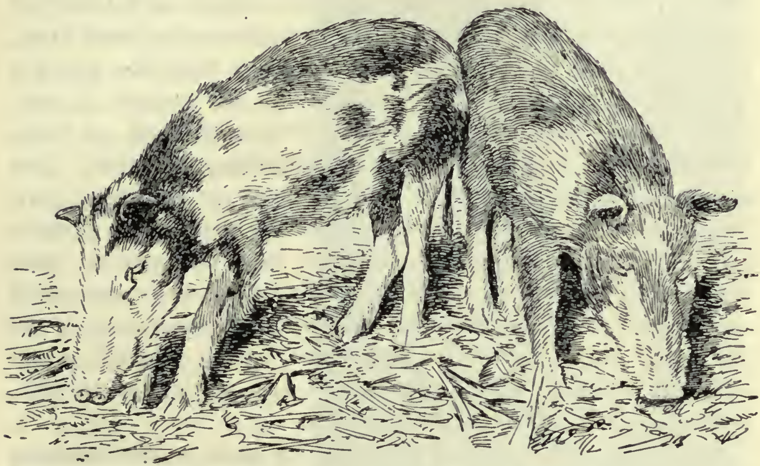


FIG. 120. — Razor backs. The next generation should show the improvement represented in figure 119.

Food Administration and its suggestion for stabilizing prices of hogs and (2) the cost of producing pork in terms of corn. Herbert C. Hoover, Food Administrator, appointed a commission of seven representative hog men to investigate and report their findings regarding the cost of producing pork. This the committee did in terms of number of bushels of corn required to produce 100 pounds of pork. The committee found that in every instance when swine on foot were sold for less money than the price of 11 bushels of corn, the number of hogs in the United States decreased,

but when hogs brought more per 100 pounds than the price of 11 bushels of corn then the number of hogs in the country increased. The commission in a report dated October 27, 1917, states: "While hog production for the ten years ending 1916 has been maintained on a ratio of 11.67 bushels of corn to 100 pounds of hogs produced, we believe, when all the losses are taken into account, that it is doubtful whether there has been a profit on the business with this ratio on the average."

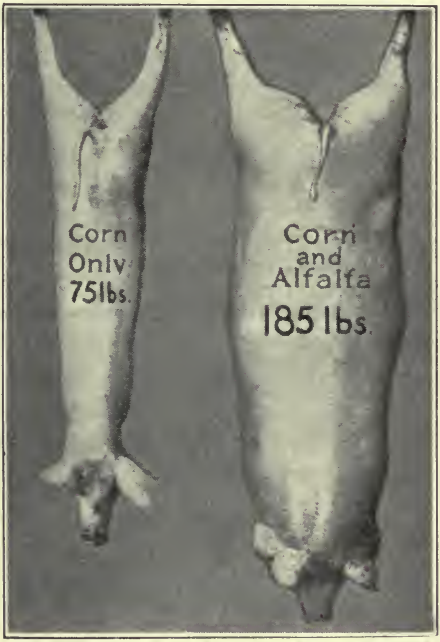
To insure stability of pork production, there should be a guarantee by the government protecting the breeder and feeder of swine against the fluctuating prices set by the commission firms. The ideas of the commission were excellent regarding fixing a definite ratio of corn required to produce 100 pounds of pork. Their notion was that, since there was a shortage of hogs, a ratio of 13 : 1 be made in order to stimulate production. This means that farmers would be paid for each 100 pounds of pork the value of 13 bushels of corn. Since the price of corn varies a great deal for different months of the year, the price set upon the corn is to be the average of the prices, not alone for the month in which the hogs are marketed, but during all the months of the life of the hogs. Such an arrangement, it was thought, would stimulate and stabilize the production and marketing of swine, an important factor in pork production.

Others estimate the cost of producing pork in the following way. — A bushel of corn will produce 10 pounds of pork; then hogs can be sold for $5.00 per hundredweight if corn is selling for 50 cents per bushel. Here is a statement often heard among hog men.

$.50 corn $5.00 per hundredweight for hogs
$1.00 corn $10.00 per hundredweight for hogs
$1.50 corn $15.00 per hundredweight for hogs
$2.00 corn $20.00 per hundredweight for hogs

These figures are about correct; but there are other points to remember that are not considered in the figures, such as the cost of keeping the parent hogs, losses due to disease, the value of money invested in buildings, land, etc., necessary to produce the swine.

6. *Feeding a balanced ration* is an important factor in getting economic returns. The two pictures below are worthy of study, each representing a lot of 7 pigs. Lot I were fed corn alone in a dry lot for 180 days. Lot II were fed corn and had access to an alfalfa pasture for 80 days and then were fed corn and alfalfa hay for 100 days. The pigs in Lot II averaged 185 pounds at the expiration of 180 days, but those in Lot I weighed an average of only 75 pounds. The pigs of Lot I made gains at a cost of $31.49 per hundredweight, while those of Lot II made 100 pounds gain at a cost of $6.68. The 14 thigh bones of the hogs fed upon corn and alfalfa had an average breaking strength of 1370 pounds; while the 14 thigh bones of the hogs of Lot I fed corn alone had an average breaking strength of 570 pounds.[1]



Courtesy Kansas Experiment Station.

FIG. 121. — Corn and alfalfa were a fairly good ration. Corn alone did not give good results. Alfalfa balances the rations if fed with corn.

The experiment shows the relation of a balanced ration to economical pork production. Corn alone is not a good ration for either growing or fattening swine. Corn alone does not ordinarily make economical gains.

Forage crops have proved very valuable in economical pork production. At the University of Missouri forage crops were

[1] Kansas Station Bulletin 192.

tried out over a period of five years to determine their value in pork production. At the same time five trials in dry lot feeding were conducted. The following average results are quoted from the bulletin.

Cost of Pork with Grains

Dry Lot Feeding

The average results of 5 lots fed differently is given in the following:

What Hogs Were Fed		Pounds Grain per Pound Gain	Pounds Gain per Bushel Corn Fed	Value of Pork Produced. per Bushel of Corn Fed Pork at 6¢
2 lots	Corn, 6 parts . . . . . Linseed oil meal, 1 part .	5.11	11.0	$0.66
2 lots	Corn, 2 parts . . . . . Shorts, 1 part			
1 lot	Corn, 3 parts . . . . . Alfalfa meal, 1 part . . .			

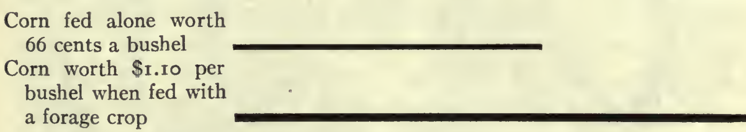
Economy of Forage Crops in Pork Production

	Pounds Grain per Pound Gain	Pounds Gain per Bushel Corn Fed	Value of Pork Produced per Bushel of Corn Fed on Forage Pork at 6¢
Blue-grass	4.50	12.4	$0.74
Alfalfa	3.07	18.2	1.09
Red clover	2.95	18.9	1.13
Rape	2.74	20.4	1.22
Rape and oats	3.60	15.5	.93
Rape, oats and clover .	2.47	22.6	1.36
Sorghum	4.00	14.0	.84
Cowpeas	3.58	15.6	.94
Soy beans	3.00	18.6	1.12
Rye grain	1.96	28.5	1.17
Average for all forage crops	3.18	18.4	$1.10

When the two tables are compared, it will be noted that it required 5.11 pounds of grain to produce a pound of gain when grain was fed alone; but only 3.18 pounds of grain were required when fed with forage crops. Grain when fed alone made 11.0 pounds of pork and when fed with forage crops 18.4 pounds, showing a saving of 38 per cent of grain. The value of a bushel of corn when fed alone was 66 cents, and when fed with forage crops its value was $1.10.

Graphically a bushel of corn had the following relative values when fed alone and fed with forage crops.

Relative Value Corn Fed Alone and with Forage Crops



Skim-milk has proved to be an excellent supplement to corn in feeding swine, as the following experiments well show.

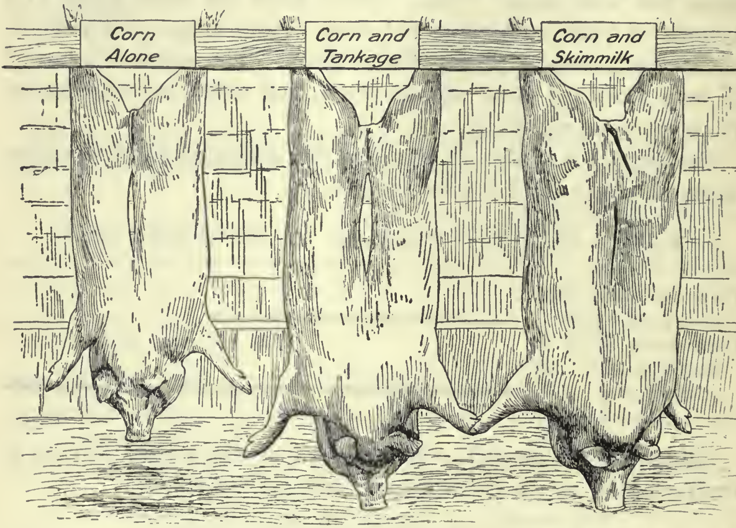
Value of Skim-Milk in Feeding Hogs

Station	Ration	Pounds of Feed to Make 100 Pounds Gain	Cost of 100 Pounds Gain
Alabama [1]	Corn alone	670	$8.38
	Corn, 1 part; Skim-milk, 2.2 parts	210	4.02
Missouri [2]	Corn, 3 parts	310	
	Wheat middlings, 2 parts	207	6.98
	Corn, 1 part	243	
	Skim-milk, 2.7 parts	559	4.71

Prices of feed corn 70 cents a bushel, skim-milk 30 cents per hundredweight and middlings $1.50 per hundredweight.

[1] Alabama Bulletin No. 82. [2] Missouri Bulletin No. 79.

From the table it may be seen that at the Alabama Station the skim milk supplement to corn cut the cost of production more than 50 per cent; at the Missouri Station the cost with a skim-milk



Courtesy Indiana Exp. Station.

FIG. 122.

FEEDING PIGS CORN ALONE IS NOT PROFITABLE—RESULTS OBTAINED AT INDIANA EXPERIMENT STATION

TEN PIGS IN EACH LOT, 70 DAYS

	Corn alone Lb.	Corn tankage Lb.	Corn buttermilk Lb.
Average initial weight	79.00	79.50	78.50
Average final weight	99.00	173.50	206.50
Gain per pig	20.00	94.00	128.00
Feed per pound gain			
Corn	8.06	2.90	2.35
Tankage		.41	
Buttermilk			6.94
Average daily gain	.29	1.34	1.83
Cost per 100 lb. gain	$8.64	$3.92	$4.08

Cost of feed: — Corn, 56 cents per bu.; tankage, $50 per ton; buttermilk, 25 cents per 100 lb.

supplement was about $\frac{2}{3}$ of the cost of production with corn and wheat middlings.

Every farmer knows the value of skim-milk and buttermilk in pork production, and it would be well for every farmer to familiarize himself with the feeding value of tankage. Tankage is a by-product in the slaughter houses, and is composed of meat scraps, ground bones and fat trimmings. It is high in protein, and should make only a small fractional part of the entire ration (about one part tankage to 12 or 14 parts other feeds). The value of buttermilk and tankage in feeding hogs in comparison to feeding corn alone is well shown by the opposite picture and data from the Indiana Experiment Station. The figures are self-explanatory.

7. *Care and management of hogs.* — Proper care and management is a seventh important factor in pork production. When the pigs are born it is important that such care be extended that all pigs born are saved. If one pig out of a litter of 8 is lost, it means that $12\frac{1}{2}$ per cent of the litter is lost. Pigs born during damp chilly weather should be placed in a box containing a bottle of hot water, covered with a blanket. Another blanket may be placed over the top of the box. This will help to dry the pigs, and helps to maintain their vitality.

Sunshine and exercise are important factors in keeping pigs and hogs strong and vigorous. Sunshine is the best natural disinfecting agent, and exercise keeps the pigs in good physical condition. Piggeries should be placed so that sunshine can get into them, and they may also have boards so arranged that the hogs may get in the shade, if they desire to do so. Portable houses are very warm in summer, but if no other shade is available, temporary shade can be added in the shed roof house.

A portable hog house, 10 by 12 feet, will accommodate two sows at farrowing time, or 8 to 10 mature hogs. The house may be moved occasionally. This is a very important factor in keeping out disease.

Pigs of unequal size should not be kept together, for it is difficult to secure economical growth under such conditions.

8. *Diseases of hogs.* — Most of the diseases of hogs can be prevented. Clean, sanitary and comfortable quarters; a well-balanced ration; and the immediate isolation of diseased hogs go a long way in preventing and controlling hog diseases. Pens and piggeries should be clean and dry and free from direct draughts but well ventilated. They should admit the sunshine and contain enough bedding so that hogs may be comfortably housed.

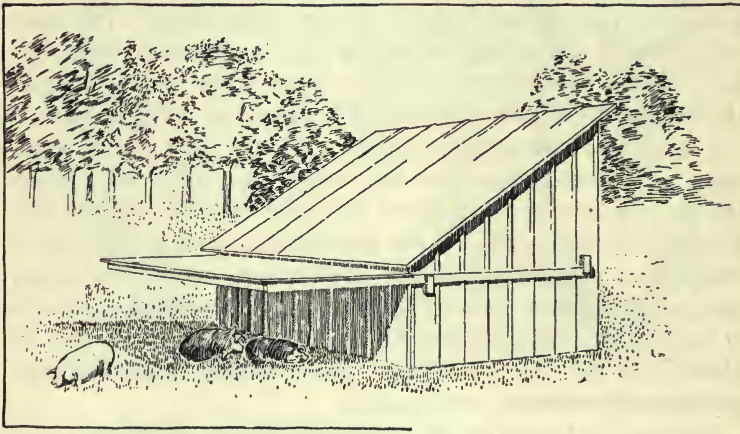


FIG. 123. — Large portable hog house with shade attached.

These preventive measures help much in keeping out disease and making hogs profitable.

Lice and worms. — Hogs must be kept free from lice and worms if they are to make gains. Lice may be destroyed by spraying with or dipping hogs in a two per cent creolin dip or by a similar use of crude petroleum. A second treatment about eight days after the first is advisable, for the first dip does not always destroy all the lice and eggs which may be deposited in protected creases back of the ears and in the pits of the limbs.

Worms also reduce the vitality of hogs. These may be removed by keeping the hogs off feed from the night before until about ten o'clock the following day. Then an ounce of santonin (white

powdery compound) for each 150 pounds of live weight should be fed with the slop. Follow this treatment about eighteen hours later with a good physic, which may be composed of $1\frac{1}{2}$ teaspoonfuls of epsom salts for each 150 pounds live weight. The physic may be fed in slop. The University of Minnesota[1] suggests the following remedy for worms. "One teaspoonful of lye dissolved in water is enough for three pigs weighing 50 pounds each. Pains should be taken to dissolve the lye very carefully and to mix it very uniformly with the feed. This should be fed for a couple of days in succession; and if fed every other week for a couple of weeks, will give results."

The University of Missouri[2] keeps the following mixture before its hogs constantly as a tonic to keep the hogs in good condition.

Glauber's salts	3 parts
Salt	3 parts
Sal soda	3 parts
Copperas	3 parts
Sulphur	1 part

Hog cholera. — The average annual loss from hog cholera in the United States for the last forty years has been about $30,000,000. In 1917, 2,959,322 hogs died of cholera. These are the direct losses resulting from death. The indirect loss is not known. Cholera is caused by a small unidentified germ. These germs may be carried by birds, dogs, cats, pigeons, buzzards, men, streams, wagon wheels and by other agencies.

The symptoms of hog cholera may vary somewhat for there are two forms of the disease, acute and chronic. However, about the first symptom is that a few hogs of the herd will refuse to come up to feed. They may probably be found in their nest and they are either chilly or feverish. Their normal temperature of 101° to 104° Fahr. may rise to 104° or 106° Fahr. If any hogs die of the cholera they may be cut open and a post mortem examination made. Bulletin No. 834 of the Federal government gives the following post mortem symptoms:

[1] Bulletin No. 4. [2] Bulletin No. 110.

1. Purple blotches on the skin.
2. Blood-colored spots on the lungs, on the surface of the heart, on the kidneys, and on the outer surface and inner lining of the intestines and the stomach.
3. Reddening of the lymphatic glands.
4. Enlargement of the spleen, in acute cases.
5. Ulceration of the inner lining of the large intestine.

Upon finding that cholera is on the farm all sick hogs should be isolated and put in a mouse and bird proof place. This may prevent the disease from spreading and when the hogs have recovered from the disease the small place can be easily disinfected with lime, a cheap and effective disinfectant. After six or seven days it may, with the litter of the pen, be hauled into the field.

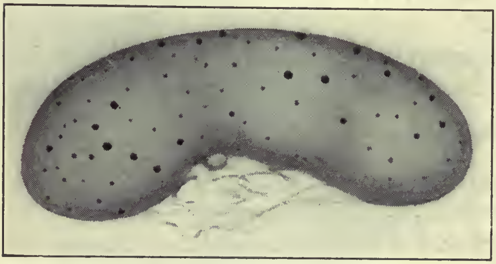


Fig. 124. — Hog's kidney, showing blood spots caused by cholera.

There are two ways of inoculating hogs for cholera: (1) By the use of serum alone (single treatment) and (2) by the use of serum and virus (simultaneous treatment). The single treatment lasts for 60 to 90 days, while the double treatment immunizes hogs against the cholera for life. Both ways have been found to be about equally efficient in preventing hog cholera.

Community coöperation is important in stamping out hog cholera. Posting the proper sign, "Hog cholera here," will aid in protecting the neighborhood. Proper feeding, providing good clean quarters, keeping the hogs thrifty and free from lice and worms, cleaning the piggeries, and using disinfectants when needed do much in preventing hog cholera.

Mange is not an uncommon skin disease of the hog. It is caused by small parasites. The skin around the ears and neck and over the shoulders is usually attacked first. The disease is contagious.

The following lime sulphur dip is recommended: Slake 4 pounds of fresh lime with water to make a thick paste, add to this lime paste 12 pounds of flowers of sulphur, and mix thoroughly. Then put this in a vessel of 30 gallons of water for one hour. Then add enough water to make 100 gallons of the mixture. It may be used as a dip or a sprinkle. The temperature of the dip should be about 108° Fahr. when used. Two treatments about eight days apart are recommended.

Summary. — Hogs are a source of much wealth in the United States, and the saying that "hogs are the mortgage lifters" is true. Pork production has several advantages; hogs multiply rapidly, they require comparatively little feed to secure 100 pounds gain, they dress out well, they eat a lot of waste foods, they are manufacturers, they help in maintaining the fertility of the soil, they are raised on a small outlay and they mature rapidly.

There are two types of swine, — the lard and the bacon type. The lard breeds are the Poland China, Duroc Jersey, Berkshire, and the Chester White. The bacon type comprises the Large Yorkshire, the Hampshire and Tamworth.

The important factors in economic pork production are: (1) Improvement of the herd; (2) The use of forage crops; (3) The raising of hogs at the right season; (4) Finishing hogs well, and making them weigh about 250 pounds when marketed; (5) Knowing the cost of pork production; (6) A properly balanced ration; (7) Proper care and management; and (8) The prevention of disease. When each of these factors in pork production is duly considered we may expect to be fairly successful in producing pork economically, but when one or more of these factors is neglected, the cost of production is greatly increased and often entire loss may occur.

QUESTIONS

1. Compare the importance of pork production with the production of other farm animals.
2. Name the advantages of pork production.
3. Classify swine.

4. Name two favorable points of three breeds of hogs.

5. What are some of the factors which aid in economical pork production?

6. What plants provide excellent forage for swine?

7. What are some of the desirable features of any breed of hogs?

8. What are some excellent hog feeds? What is each feed worth per ton?

9. Balance one winter and one summer ration for hogs according to the Wolff-Lehmann standard.

10. Compare the food value, in its composition and calorific value, of pork with porterhouse steak, butter and navy beans.

PROBLEMS

1. Report on how the number of pounds of hogs may be increased without increasing the cultivated crops.

2. Report on some bulletin or chapter that discusses the topic of "Forage Crops in Pork Production."

3. Report on losses due to hog cholera and method of control used on a farm or in the community.

REFERENCES

Gay, Productive Swine Husbandry.
Plumb, Types and Breeds of Farm Animals.
Henry and Morrison, Feeds and Feeding.
Bailey's Cyclopedia, Vol. III.

ADDRESSES OF SWINE BREEDERS' ASSOCIATIONS

American Poland China Record Ass'n, W. M. McFadden, Sec., Chicago, Union Stock Yards.

American Berkshire Ass'n, F. S. Springer, Springfield, Ill., 510 E. Monroe St.

American Duroc Jersey Swine Breeders' Association, R. J. Evans, Chicago, Union Stock Yards.

CHAPTER XX

SHEEP PRODUCTION

Importance. — On January 1, 1918,[1] there were 48,900,000 sheep in the United States. This is less than one-half sheep per person and calls our attention to the fact that the number of sheep in the United States is comparatively very small. The income from sheep is about one-third as much as the income from poultry.

The sheep states are mostly in the plains of the West, though the states of Ohio and Texas are among the leading sheep states. Wyoming, Montana and New Mexico produce almost 25 per cent of all our sheep. The following graph shows at a glance the leading sheep states.[2]

		0% 3% 6% 9%
Wyoming	4,338,000	8.6%
Montana	3,941,000	8.0%
New Mexico	3,440,000	6.8%
Idaho	3,102,000	6.1%
Ohio	3,067,000	6.0%
Oregon	2,563,000	5.2%
California	2,450,000	5.0%
Texas	2,156,000	4.3%
Utah	2,089,000	4.2%
Arizona	1,849,000	3.7%
Nevada	1,532,000	3.1%
Missouri	1,416,000	2.8%
Rest of United States		36.2%

Advantages of sheep production. — Sheep raising has many advantages; several very substantial ones. These will be briefly summarized. 1. Sheep are often called the plant scavengers

[1] *Crop Reporter.* [2] United States Yearbook of Agriculture, 1916.

of the farm. They eat 90 per cent of all the weeds found in the average farm pasture, while cattle and horses eat less than 50 per cent of them. This is a great advantage, for sheep make use of a waste product that otherwise is not only a waste product but a positive harm upon the farm. Craig tells us: "Weedy cattle pastures into which sheep have been turned have been found to carry the sheep and added number of cattle after the weeds were destroyed and the grass given a fair chance for growth." [1]

2. Sheep, because of their fleece, can be grown in high altitudes where the low temperature often prohibits the growth of other live stock. It is for this reason too that sheep do not require expensive stables, because sheep stables need not be built so much for warmth as to keep the sheep dry.

3. The labor requirement for sheep production is not very large. The amount of fencing, building and feeding is not great. Their feeds are roughages which require little cost in their production. In fact they save labor by clearing the farm of noxious weeds and shrubs.

4. Sheep bring good returns twice a year, when the fleeces are sold and when the lambs and sheep are sold for mutton. The returns from sheep are quick and reasonably certain. The demand for wool is very strong, and mutton brings a fair price. The growers of the Western ranges have stressed wool production; the Central States, because of additional concentrated feeds, emphasize mutton production. A thoroughgoing combination of wool and mutton production may be well considered.

Classification of sheep. — Sheep are produced for two purposes, wool and mutton. While all breeds produce both wool and mutton, sheep, according to the characteristics of the wool produced, are further divided into three classes: (1) Fine wool breeds; (2) Middle wool breeds; (3) Long wool breeds. Each will be briefly discussed. For fuller treatment on each breed refer to Plumb's *Types and Breeds of Farm Animals.*

1. *The fine wool breeds* include the following three breeds. Some of the characteristics of each are given.

[1] *Sheep Farming.*

	Native Home	Color of Points	Size, Pounds	Length of Wool, Inches	Diameter of Wool, Inches	Weight of Fleece, Pounds
American Merino . .	United States	White	100–150	$2–2\frac{3}{4}$	$\frac{1}{1194}$	12–25
Delaine Merino . .	United States	White	100–150	3–5	$\frac{1}{1194}$	10–20
Rambouillet .	France	White	150–185	3–4	$\frac{1}{1194}$	10–15

The fine wool breeds have smooth, wrinkled, or slightly folded skins. The folded skin increases the wool producing area. The wool on the Merinos is dense but short. The fine crimp in wool is very desirable; and the fineness, the crimp and the extra yolk in Merino wool give it its special value. The wool from the fine wool breeds is made into the finest fabrics. It is said upon good authority that during the days of Ferdinand of Spain shawls were made of such fine wool that they could be pulled through a finger ring.

The Merinos correspond to the dairy cow, for they are skinny and angular and have a specific purpose. All their feed not needed for maintenance is used for wool production. Since wool is nitrogenous, the feed should be to some extent of that nature. Good feeding and good wool go together.

On page 324 is a picture of a Merino ram of Class A. Class B has fewer folds, and Class C has practically a smooth covering.

2. *The middle wool breeds*, and some of their characteristics follow:

	Home	Color of Points	Size, Pounds	Length of Wool, Inches	Diameter of Wool, Inches	Weight of Fleece, Pounds
South Down . .	England	Gray	125–175	2–3	Varies but ranges from about $\frac{1}{500}$–$\frac{1}{900}$ inches	4–8
Hampshire Down	England	Dark brown	180–250	3–4		5–8
Oxford Down .	England	Brown	200–325	4–6		6–10
Suffolk Down .	England	Black	180–240	3–5		5–8
Shropshire Down	England	Dark brown	155–225	3–4		8–12

The middle wool breeds are also known as the Down breeds, and as the mutton breeds. They are somewhat larger than Merino sheep and have the conformation of good mutton producers. The wool is coarser and has a longer staple than that of the fine wool breeds. It is made into the woolen garments worn by the middle class of people. The longer fiber is conducive to a stronger warp and woof, making a thread which is difficult to break. Compare the breaking strength of a cotton and a woolen thread. It

FIG. 125. — Merino ram, Class A. Note the folded skin, and the dense covering of wool over the entire body, face and limbs.

will be observed that the long fiber in the wool will not pull apart but must be broken if it is to be severed. Cotton pulls apart easily.

The middle wool breeds will dress out from 50 to 55 per cent dressed carcass. They are an excellent breed of sheep for the farmers of the Middle States. The two pictures on the following page show the general characteristics of the middle wool breeds and the special characteristics of the two breeds.

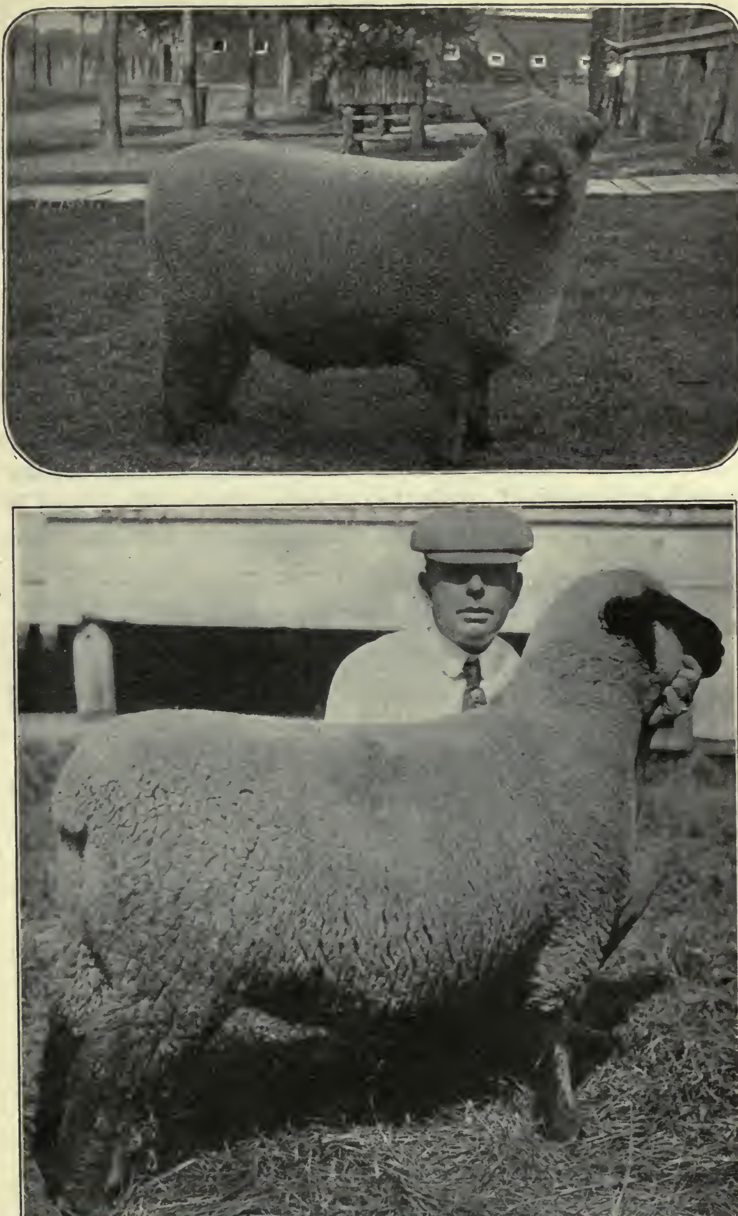


FIG. 126. — A Shropshire and a Hampshire ram. They are a middle wool type.

3. *The long wool breeds of sheep* include the following three breeds. Some points pertaining to these sheep follow:

	Native Home	Color of Points	Size, Pounds	Length of Wool, Inches	Diameter of Fiber, Inches	Weight of Fleece, Pounds
Leicester . .	England	White	180–240	6–10	$\frac{1}{400}$–$\frac{1}{600}$	6–10
Cotswold . .	England	White spotted	200–265	8–14	$\frac{1}{400}$–$\frac{1}{600}$	8–12
Lincoln . . .	England	White mottled	275–350	10–18	$\frac{1}{400}$–$\frac{1}{600}$	10–14

The long wool breeds do not shear as heavy a fleece, but for strength and length of staple they are unexcelled. Their wool is made into coarse garments, rugs and carpets.

FIG. 127. — A group of Cotswold rams. Long wool breed and mutton type.

4. **Mutton production.** — Lambs weighing 65 to 85 pounds are most in demand for mutton purposes. It is then that they bring the best prices. A ewe that will raise a good lamb or two will bring a good income for her owner. A hundred ewes of the middle wool breeds will raise from 110 to 150 lambs. These lambs having

[1] It will be of interest to examine closely the individual score cards of the different breeds of sheep as given in Craig's, *Judging Live Stock.*

a birth weight of 8 to 10 pounds (triplets 6.8 pounds, twins 8.0 pounds, and single lambs 9.5 pounds),[1] will increase to 65 to 75 pounds at the age of six months. The cost of production has been small and the price is usually good, hence the profits are excellent. For the Central States early lambs coming in January and February usually bring the best returns, for they can be got to market before the Western lambs come on. The native lambs are sold chiefly in May, June and July.

Western lambs are from west of the one hundredth meridian. These lambs constitute 75 to 80 per cent of the Western sheep trade. The Western lambs are marketed over a long period, and usually begin to come into the market by July 15. However, most of the Western lambs are marketed through the months of August, September and October.

Some Western lambs are marketed as feeders in August and September to farmers of the Middle States where corn and soy beans are grown in the summer. These Western lambs are pastured in these fields and usually do well on soy beans and corn. The price is generally two to four cents per pound less when they are sold as feeders than when they are sold for the block.

Captain A. C. Todd of Leeton, Missouri, September 13, 1914, bought 658 Western lambs, weighing 54 pounds per head, at a cost of $6.75 per hundredweight. These lambs were pastured on 120 acres of soy beans sown in corn for 52 days. Then 638 lambs were sold, November 4, 1914 (18 lambs being killed by dogs and two crippled), at $8.65 per hundredweight. The lambs averaged 68 pounds.

Recapitulation:

Gross receipts	$3,674.43
Total cost of lambs plus car fare	2,635.21
Net gain	1,012.22
Net gain per head	1.52

This practice has several advantages: (1) Prevents lambs going to slaughter half fat; (2) Increases the total mutton out-

[1] Humphrey and Kleinheintz, Report 1907.

put; (3) Amalgamates the farm interests in different sections of the nation, an important thing; (4) Improves the fertility of the soil.

5. **Factors in economical sheep production.** — The following factors are important in sheep production: (1) Size of the flock; (2) Shelter for sheep; (3) Taking care of the lambs at lambing time; (4) Docking lambs; (5) Improvement of herd by breeding; (6) Protecting sheep from their enemies; and (7) Feeding sheep properly.

1. *Size of the flock.* — Craig says:[1] "The reputation Canada has made as a sheep country has been due to its small flocks; ten to twenty on almost every farm. Very rarely indeed are as many as 40 breeding ewes found on one farm. American farmers' inclination to vacillate and go to extremes has been greatly to their disadvantage. At times they have scrambled over each other to buy sheep, often getting more than they were prepared to keep well, and again as frantically trying to dispose of all."

Where general farm operations will allow, it is probably more economical to have not fewer than 30 ewes, nor more than 60. Ewes may be kept until they are five years of age. This gives an excellent chance to elevate the stock for prolific ewes, and the progeny of the best may be kept. The adult flock may be replenished 20 to 50 per cent annually. With such opportunity for selection the flock may be improved, for all the weaklings can be culled out.

The reason for not keeping a very small flock is well stated in the following words:[2] "The economical disadvantage of a very small flock lies in the fact that the hours of labor are practically the same for a dozen or twenty ewes, as for the larger flock. The fencing to allow desirable change in pasture or to give protection against dogs is about the same in either case; so that the overhead charges are much smaller per ewe in the case of the larger flock."

2. *Shelter for sheep.* — Sheep more than any other animal must be kept dry, — not only in the winter, but in the spring and

[1] *Sheep Farming.* [2] Farmer's Bulletin No. 840.

summer as well. Barns made with one thickness of well-matched lumber are warm enough. Basement barns are not recommended for sheep. Good ventilation is essential, but direct air currents must be avoided. In the West, sheep must be protected from the winds.

If sheep get wet, it requires several days for them to dry. It is due to the evaporation of the moisture on their bodies that they often get sick and die. The resistance to disease is lowered by a cold, damp body.

The value of the fleece of sheep is lowered by getting wet. Good wool contains from 25 to 35 per cent of yolk when sheared. The yolk shows that the skin secretions were good and this shows that the sheep were thrifty and in good condition. Keeping sheep dry is an important factor in sheep production.

3. *Lambing time.*[1] — Lambing time, according to the author's teacher, Professor Kleinheintz, of the University of Wisconsin, is the "harvest time" of the shepherd. Then the shepherd must remain with his flock day and night. Ewes should be given separate pens, and weakly lambs should be helped in getting their first meal. Lambs should be kept warm until their bodies become dry; sometimes they must be wrapped in a dry, stove-heated, woolen cloth. Often 20 to 50 per cent of the lambs can be saved at lambing time by extending a little help and care. This is one of the big factors in economic sheep production. The true shepherd is quiet, gentle, kindly and sympathetic. These qualities are essential to securing the best results with sheep.

4. *Docking lambs.* — In order to get the best results with sheep and lambs their tails must be docked. This may be done, if the weather is cool when the lambs are ten to twelve days old. It is advisable to dock the tails when the lambs are young, for the bone is smaller and will heal over more quickly. The tail is cut off with a sharp knife at the third or fourth joint from the body, where the under side of the tail begins to be covered with wool. The skin should be slipped as far as possible toward the

[1] From Gehr's *Productive Agriculture.*

body before cutting. The wound may be disinfected with a five per cent carbolic acid solution, and then covered with pine tar.

5. *Improvement of sheep* is an important factor in sheep production. The use of a well-conformed ram often aids in improving the flock and in augmenting the profits.

In the average farm flock there are usually a number of ewes that lack in conformation, and meat- and wool-producing ability. Their offspring may be improved to a degree by the use of a good,

Courtesy Illinois Station.

FIG. 128. — Western ewes. Note the deficiency of form, quality, and lack of leg of mutton.

well-bred sire. This in fact is one of the greatest factors in economic sheep production. Contrast figures 128 and 129.

6. *Enemies of sheep.* — The sheep-killing dog is probably the worst enemy of the sheep industry. The estimated loss for 1913 in 36 of our states was 107,760 sheep. This was a direct loss of approximately one per cent to the sheep industry. But there are other losses than the direct losses due to the killing of the sheep, for many farmers refuse to raise sheep because of the sheep-killing dog.

Although there are good dogs and bad dogs, the tribe as a whole adds very little to the agricultural or economic output of our land, and since some dogs do a great deal of harm, laws should be passed, placing a tax upon all dogs, so that only good dogs will be kept and the bad ones killed.

Courtesy Illinois Station.

FIG. 129. — Offspring of the ewes in the opposite figure and a pure bred Shropshire sire. They are producers of more and better wool and mutton than their dams were.

Sheep scab is one of the causes for large losses in the sheep industry. Sheep scab is caused by a small parasite which may be seen with the naked eye, but much better with a magnifying glass. The little mite secures its nourishment from the skin of the sheep. The area covered with the mites becomes scaly, and the wool in that section become dry, and sooner or later falls out. The infected animals becomes unthrifty, the amount of wool is reduced, and some of the sheep may die. Sheep scab and lice may be easily controlled by dipping the sheep in a lime-sulphur solution made as follows:

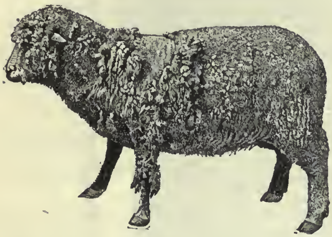


FIG. 130. — A result of sheep scab.

To 10 pounds of unslaked lime add enough water to slake to a paste. Add to this 30 pounds of flowers of sulphur and mix thoroughly. Add to this mixture 25 gallons of water and boil for about two hours. Add to this solution enough water to make one hundred gallons. The dipping solution should be at a temperature of about 105° Fahr. when the sheep are dipped. Keep the sheep in the dip at least 2 to 3 minutes. After an expiration of ten days dip again, for this destroys the newly hatched eggs. Dipping should be done during warm weather and usually after the sheep are sheared. The premises may be disinfected with lime and the troughs and salting places may be washed with salt water.

7. *Feeding sheep.* — Sheep are primarily grazing animals, ruminants, and hence require more roughages than do hogs. Forage crops of soy beans, cowpeas, rape, and rye and pastures of blue-grass and white clover for summer are excellent. The legume hays, such as alfalfa and red clover, plus some grain, such as corn, oats and wheat make a first-class ration for sheep.

Corn alone and a carbonaceous roughage will not give the best results in fattening lambs or sheep. This is well shown by the following table taken from Henry and Morrison, *Feeds and Feeding.*

CORN REQUIRES SUPPLEMENT FOR FATTENING LAMBS

	Initial Weight Lb.	Daily Gain Lb.	Feed for 100 Lb. Gain	
			Concentrates lb.	Hay lb.
Unbalanced ration, 164 lambs:				
Corn, 0.9 pound				
Carbonaceous hay 1.0 pound	59	0.19	497	547
Balanced ration, 172 lambs:				
Corn, 1.1 pounds				
Legume hay, 1.5 pounds	59	0.32	340	475
Unbalanced ration, 90 lambs:				
Corn, 1.2 pounds				
Timothy hay, 1.0 pounds	64	0.23	520	448
Balanced ration, 90 lambs:				
Corn, 1.2 pounds				
Cottonseed, or linseed meal, 6.2 pounds				
Timothy hay, 1.0 pound	64	0.30	463	334

The table clearly shows the value of a legume or a nitrogenous concentrate for fattening lambs. Lambs fed corn and carbonaceous hay made a daily gain of 0.19 pound; and those fed corn and legume hay made a daily gain of 0.32 pound. It also required only about three-fourths as much feed to put on 100 pounds gain when legume hay was fed.

Lambs are more economical fatteners than are old sheep.

FATTENING RANGE SHEEP OF DIFFERENT AGES [1]

	Lambs	Yearling Wethers	Two-Year-Old Wethers	Aged Ewes
Average initial weight, pounds	63	95	116	92
Average daily gains, pounds	0.27	0.27	0.28	0.18
Average ration: Clover hay, pounds	2.1	3.8	4.1	2.3
Average ration: Barley, pounds	0.68	0.68	0.68	0.68
Feed per 100 pounds gain: Clover hay	763	1413	1489	1320
Feed per 100 pounds gain: Barley hay	253	256	248	387
Digestible feed per pound increase	10.2	16.6	17.1	17.5
Per cent dressed carcass	54.2	52.9	53.6	50.6

[1] Montana Station Bulletin No. 35.

The table clearly indicates the relation of age to the amount of feed required to produce 100 pounds gain. Lambs used 10.2 pounds digestible feed to put on one pound gain, and the other groups 16.8, 17.1 and 17.5 pounds respectively.

A few rations for fattening lambs weighing from 80 to 100 pounds follow:

1. Two-thirds pound corn plus 3 pounds alfalfa hay.
2. One pound of corn plus 2 pounds alfalfa and 2 pounds of oats.
3. Two pounds of clover hay plus 1 pound of corn and one-half pound of wheat bran.

Summary. — The sheep states are principally in the plains, where conditions exist that make sheep raising advantageous. The number of sheep is comparatively small, and may be increased upon the average farm without much additional expense, for they eat weeds that are harmful and thus renovate the pastures and produce a valuable product. There are three classes of sheep, fine, middle and long wool breeds. The last two are often classed as mutton producing sheep. The size of the flock, shelter, care at lambing time, docking, combating their enemies, such as dogs and mites, and feeding properly are the large factors in sheep production.

QUESTIONS

1. Discuss the importance of the sheep industry in the United States.
2. Discuss the advantages of sheep production.
3. Describe the different types of sheep.
4. What natural advantages has your locality for sheep production? What disadvantages?
5. What are the factors aiding in economic sheep production?
6. Describe in detail two breeds of sheep.
7. Give in detail the score card for fine wool sheep.

PROBLEMS

1. Report on the "Diseases of Sheep."
2. Compare the prices on foot and the per cent of dressed carcasses of sheep, beef cattle and swine.

REFERENCES

Craig, Sheep Farming.
Harper, Animal Husbandry for Schools.
Henry and Morrison, Feeds and Feeding.
Gehrs, Productive Agriculture.

ADDRESSES OF A FEW SHEEP BREEDERS' ASSOCIATIONS

The American and Delaine Merino Record Ass'n, S. M. Cleaver, Sec., Delaware, Ohio.

American Hampshire Sheep Ass'n, C. A. Tyler, Detroit, Mich., 36 Woodland Ave.

National Lincoln Sheep Breeders Ass'n, Bert Smith, Charlotte, Mich.

American Cotswold Registry Ass'n, F. W. Harding, Waukesha, Wis.

CHAPTER XXI

PRODUCTION OF POULTRY

Importance of the poultry industry. — Although some think that poultry production is relatively unimportant, the income from poultry ranks above that from hogs, sheep, or dairy cattle. The annual income from poultry is nearly $750,000,000, or about $7.50 per person in the United States, while hogs, sheep and dairy cattle have to their credit $4.00, $2.50 and $6.00 per capita respectively.

The income from poultry products on the average farm is sufficient to purchase the groceries, clothes and school books. Bank deposits are not greatly augmented from poultry products, but the income from this source permits the income from other farm sources to be deposited. The average annual farm income from the sale of eggs was $60.57, and from fowls $31.82.[1]

The ten most important poultry states in the order of the value of their poultry are, according to the 1910 census, as follows:

THE TEN LEADING POULTRY STATES

Iowa	$ 12,270,000
Missouri . . .	11,871,000
Illinois . . .	11,697,000
Ohio	9,533,000
New York . .	7,879,000
Indiana . . .	7,762,000
Pennsylvania .	7,674,000
Kansas . . .	7,377,000
Michigan . .	5,611,000
Texas	4,807,000
United States .	154,663,000

[1] Census 1910.

The above ten states had 55.9 per cent of the total value of all poultry in the United States.

Advantages of poultry production. — The advantages of poultry production vary under different conditions, and therefore the more general ones will be given.

1. One of the first advantages of poultry production is that fresh eggs and meat are provided for immediate family use. Since eggs and poultry meat are very rich in protein ingredients they furnish a large part of the elements valuable in the human diet.

2. The returns from poultry are fairly safe and substantially remunerative. Exorbitant profits should not be expected from poultry raising, but under average conditions fair profits may be expected.

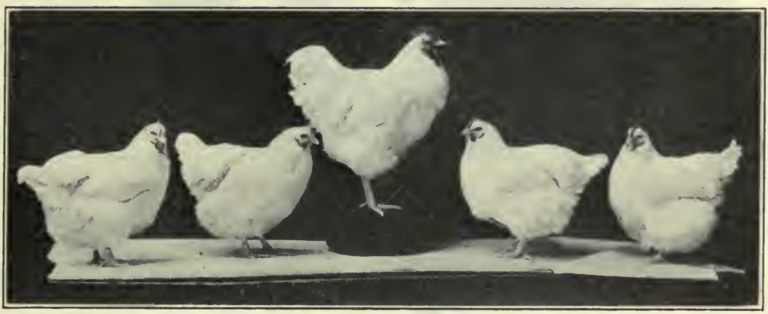
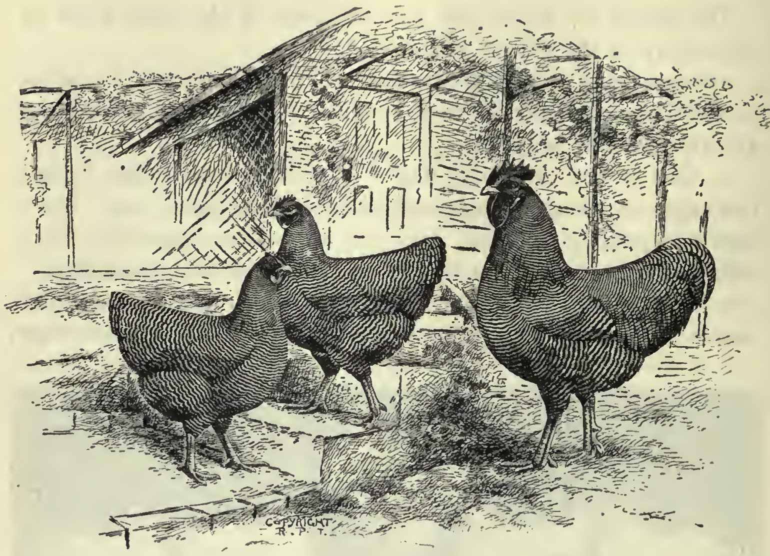


FIG. 131. — The Eggiman strain of white Orpingtons. The above fowls are owned by O. E. Eggiman, Cape Girardeau, Mo.

3. Poultry can be produced in small, closed pens. A broad acreage is not required. It is remarkable how chickens thrive in confined quarters. The city lot may produce some poultry products, although 90 per cent of the fowls raised in the United States are produced upon farms.

4. It requires little capital to raise poultry. From 500 to 600 fowls may be kept on five or six acres, and the buildings and other equipment need not be expensive. The initial cost of starting in the poultry business need not be large.



Barred Rocks.

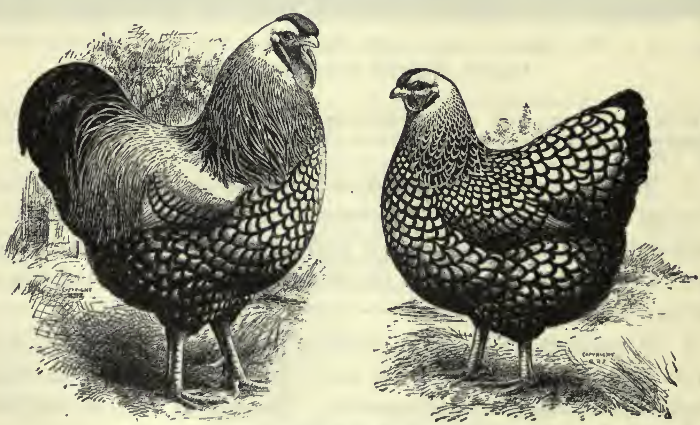


FIG. 132*a*. — Silver Wyandottes.

Single Combed Brown Leghorns.

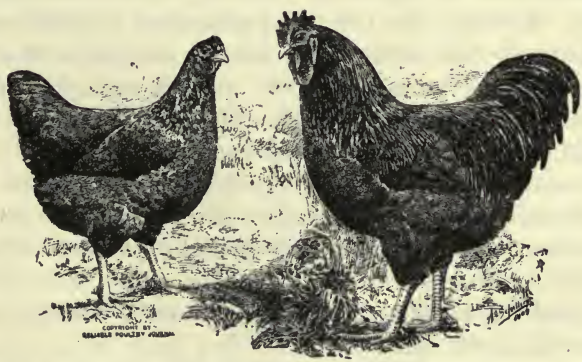


FIG. 132*b*. — Single Combed Rhode Island Reds.

5. Poultry raising improves the fertility of the soil. Poultry manure is the richest of all farm manures. A ton of poultry manure contains 32 pounds of nitrogen, 32 pounds of phosphorus and 16 pounds of potash. As garden or truck patch manure it has no equal.

6. Poultry utilizes as food many waste products. Skim-milk, buttermilk, waste grains, waste grass, wheat screenings, insects and table scraps make a large part of the feed. These cheap or inferior products are thus transformed into a highly valuable and easily marketable product.

7. Poultry production is adapted to either sex. Although practically the entire poultry output is the work of women, men can raise poultry successfully. Even children's time may be profitably devoted to the raising of chickens.

8. Poultry products are easy to market. Eggs with their convenient size and form and with the shell covering may be marketed at any distance. Fowls may be shipped around the world. Not only are they easily marketed, but they are of a very convenient size for table use.

9. Poultry brings quick returns. Eggs may be marketed the day they are produced. Broilers are ready for the market in ten to twelve weeks, and friers in four to six months.

Classification of poultry. — There are two classifications of poultry; namely, the utility classification and the standard classification. The utility classification consists of the following three general groups of fowls: the egg type, the meat type and the dual purpose type. This classification we shall not use but shall deal mainly with the standard classification.

The standard classification of poultry underlies the making of the book, *The Standard of Perfection.* According to this classification there are 14 classes, 38 breeds, and 109 varieties of poultry. In order to understand this classification we must know the meaning of the terms "class," "breed" and "variety" as used in connection with poultry.

The word "class" refers to the nativity of the fowl. For

illustration, the Plymouth Rocks were originated in America, and therefore they belong to the American class of fowls. Again, the Leghorns belong to the Mediterranean class because they originated in Italy and along the Mediterranean Sea. The Asiatic and English classes were originated in Asia and England respectively.

The word "breed" refers to shape. For illustration, all Plymouth Rocks have the same shape. All Wyandottes have the same shape. And again all Leghorns, Orpingtons, Langshans, or any other breed of fowls have each a specific breed shape. The figures on page 338 and 339 illustrate breed characteristics.

The term "variety" refers to the color markings of fowls. There are six varieties of the Plymouth Rock breed. All of these fowls are alike except in color. They have the same weight and shape, and have a single comb; the only difference is their color. This difference in color gives them the variety name. However, in some instances the kind of comb determines the variety name.

Having learned the terms "class," "breed" and "variety" as used in poultry husbandry, it is now appropriate to give the standard classification of fowls. For additional information refer to *The Standard of Perfection*. See pages 342 and 343.

Every school should have a copy of *The Standard of Perfection*, and the standard weights, shape characteristics and the color markings of several varieties of fowls should be studied. Not only this but some judging of fowls should be done, for then the study of poultry becomes more concrete and interesting.

Scrubs, cross bred, grades and pure bred. — *A scrub fowl* is one which carries a very small amount, if any, of the blood of an improved breed. Sometimes the term "scrub" may refer to the native, original fowls. The *Aseel* and the *Gallus Bankiva*, the native fowls from which our improved fowls come, were scrubs.

A cross bred fowl is the progeny from two pure bred fowls. Thus the progeny from a White Rock and a White Wyandotte would be a Rock-Wyandotte cross.

Standard Classification of Fowls and Weights of Adults

Class	Breed	Varieties	Weight	
			Cocks	Hens
American	Plymouth Rocks	Barred, White, Buff, Silver Penciled, Partridge, and Columbian	9½ lb.	7½ lb.
"	Wyandotte	Partridge, Golden, White, Buff, Black Silver, Silver Penciled and Columbian	8½ lb.	6½ lb.
"	Java	Black and Mottled	9½ lb.	7½ lb.
"	Rhode Island Red	Rose and Single Comb	8½ lb.	6½ lb.
"	Dominique	Rose Comb	7 lb.	5 lb.
"	Buckeye	Buckeye	9 lb.	6 lb.
Asiatic	Brahma	Light and Dark	12 lb.	9½ lb.
"	Cochin	Buff, Partridge, White and Black	11 lb.	8½ lb.
"	Langshan	Black and White	9½ lb.	7½ lb.
Mediterranean	Leghorn	Single Comb, Brown, White, Buff and Black; Rose Comb, Brown, White, Buff, Black	5½ lb.	4 lb.
"	Spanish	White-faced Spanish	8 lb.	6½ lb.
"	Ancona		5½ lb.	4½ lb.
English	Dorking	White, Silver, Gray and Colored	7½ lb.	6 lb.
"	Red Cap	Rose Comb	7½ lb.	6 lb.
"	Orpington	Single Comb, Buff, Black and White	10 lb.	8 lb.
Polish	Polish	White Crested, Black, etc.		
Hamburg	Hamburg	Golden Spangled and Silver Spangled, etc.		
French	Houdan		7½ lb.	6½ lb.
"	Crevecœur		8 lb.	7 lb.
Game and Game Bantams	Game and Game Bantams	Several Varieties		

Standard Classification of Fowls and Weights (*Concluded*)

Class	Breed	Varieties	Weight	
			Cocks	Hens
Oriental	Cornish	Dark, White and White Laced	9 lb.	7 lb.
"	Sumatra	Black		
"	Malay	Black Breasted Red		
"	Malay Bantam	Black Breasted Red	26 oz.	24 oz.
Ornamental Bantam	Sebright	Golden and Silver	26 oz.	22 oz.
"	Rose Comb	White and Black		
"	Booted	White	26 oz.	22 oz.
"	Brahma	Light and Dark	30 oz.	26 oz.
Polish	Polish	Bearded, White, etc.	26 oz.	22 oz.
Miscellaneous	Silkie	White		
"	Sultan	White		
"	Frizzles	Any color		
Ducks	Pekin		9 lb.	8 lb.
"	Aylesbury		9 lb.	8 lb.
"	Rouen		9 lb.	8 lb.
"	Cayuga		8 lb.	7 lb.
"	East India			
"	Muscovy		10 lb.	7 lb.
"	Runner		4 lb.	$4\frac{1}{2}$ lb.
Geese	Gray Toulouse		26 lb.	20 lb.
"	Emden		20 lb.	18 lb.
"	African		20 lb.	18 lb.
"	Chinese		12 lb.	10 lb.
"	Wild Canadian		12 lb.	10 lb.
"	Egyptian		10 lb.	8 lb.
Turkeys	Bronze		36 lb.	20 lb.
"	Narragansett		30 lb.	18 lb.
"	White Holland		28 lb.	18 lb.
"	Black		27 lb.	18 lb.
"	Slate		27 lb.	18 lb.
"	Bourbon Red		30 lb.	18 lb.

A high grade fowl is one that carries 75 per cent or more of the blood of some particular variety in its veins. A very high grade fowl is almost pure bred.

A pure bred fowl is one that carries no alien blood from any other variety in its veins. The term "thoroughbred" is often erroneously used for pure bred. "Thoroughbred" has only one application, namely, to the English Thoroughbred horse, the running horse of England.

FIG. 133. — Aseel fowl, one of the ancestors of domestic fowls. The *Gallus Bankiva* showed slightly more improvement and our light active breeds resemble them.

The question may be appropriately asked here, what are the advantages of pure bred animals or fowls over scrub animals? They are:

1. A pure bred animal or fowl transmits its characteristics to the next generation without great variation, if any. We may know what to expect. The laws of heredity are just as absolute as the laws of the Medes and Persians, and pure bred parents can have only pure bred offspring. Color, shape and general ability to function in a definite way are inherent in pure bred animal or fowl.

2. Pure bred fowls are adapted to a definite purpose. Pure bred egg types of fowls transmit quality of egg production to a greater extent than fowls bred promiscuously. No one would expect to send a pen of hens to an egg laying contest unless they had parents that were superior in egg producing ability. They must have been bred from high producers for four or five generations back.

3. Pure bred fowls have a greater efficiency in utilizing feeds. They produce more eggs or meat from a given amount of feed than do mongrels or scrubs. In fact, the *Gallus Bankiva* produces only 15 to 30 eggs a season; the average of all fowls in the United

States is 64 eggs; and there are many pure bred fowls that lay 150 to 200 eggs per year.

4. Pure bred fowls sell for more money, and especially is the sale price augmented when they or their eggs are sold for production purposes. And even on the market, eggs uniform in color, shape and size sell for more money than a mixed lot, and so will a uniform lot of fowls sell for more money than a mongrel group.

5. Pure bred fowls have a better, more attractive appearance. This is an advantage, for it instills pride in the breeder. Pride creates interest; interest creates steady care and management; and this brings profits, satisfaction and success.

6. Pure bred fowls and pure bred stock elevate the opinion of your neighbors of your stock. This is an immediate advertisement which costs nothing, but which creates a more ready sale for all breeding stock. It has been said "it pays to advertise," — and now it may be said as well and put into practice more, "it pays to breed well."

Although pure bred fowls have all the advantages over scrubs, yet it is not enough that a fowl be pure bred. For that reason we shall enumerate some of the essential characteristics of a good fowl.

The characteristics of a good fowl.[1] — A good fowl should conform very closely to the standard weight and shape of the breed to which it belongs, and have the color of its variety. This shows good breeding or improvement and indicates that its ancestors were pure bred fowls for at least six generations. A fowl should also show a good constitution. A strong beak, a broad head, a well-formed body and strong legs indicate a good constitution. A fowl with a thin, peaky, snaky head should be killed for meat. The posture and carriage of a fowl is worthy of consideration. Erectness, pride, alertness and activity are characteristics of a good fowl. An active fowl is best. A fowl that is lazy, droopy, and does not hold its feathers and body up snugly is not good. A fowl that works from early morning to late evening is the egg producer. Fowls that remain late on the roost in the morning,

[1] Paragraph quoted from Gehr's *Productive Agriculture*.

go to bed early at night, and sit on the roost a part of the day are drones and are unworthy of their keep. The hens that go farthest from the house are usually the best layers.

Other considerations which indicate good qualities in fowls are:

1. Early hatched and early maturing fowls.
2. Early laying pullets.
3. Winter laying hens.
4. Fowls that do not go broody.
5. Late moulting fowls.
6. Fowls with short, worn-down toenails. Long toenails indicate inactivity.

Egg type of hen. — It is a well-established fact that hens which are good layers have a conformation conducive to egg production, that is, their *form* and *function* are closely correlated. They possess certain physical qualities which the meat producing type does not possess. We are indebted to Walter Hogan to a large extent for working out this fact, and for a fuller treatment the reader is referred to his book entitled *The Call of the Hen.*

The characteristics which indicate the egg type are as follows: (1) Measurement of the abdominal capacity; (2) Thickness of pelvic bones; (3) Condition of breastbone; (4) A broad back of medium length; and (5) A few miscellaneous points. Each will be discussed.

1. Measurement of abdominal capacity. The depth of the abdominal capacity indicates a good or a poor feeder; and since it requires a lot of feed for a good layer, large abdominal capacity is essential. Fowls with one- or two-finger capacity are poor producers because they cannot consume and digest sufficient food. Therefore, a fowl should have a five- or six-finger capacity. Abdominal capacity is measured from the rear of the breastbone to the pelvic bones.

2. Thickness of pelvic bones. The egg yield of fowls varying in thickness of pelvic bone, and having a one-finger capacity is shown in the following table:

One-Finger Capacity (Abdomen)

Thickness of Pelvic Bone	Egg Capacity
$\frac{1}{16}$-inch	36
$\frac{1}{8}$-inch	32
$\frac{3}{16}$-inch	28
$\frac{1}{4}$-inch	24
$\frac{5}{16}$-inch	20
$\frac{3}{8}$-inch	16
$\frac{7}{16}$-inch	12
$\frac{1}{2}$-inch	8
$\frac{9}{16}$-inch	4
$\frac{5}{8}$-inch	0

The table indicates that a fowl with a pelvic bone $\frac{1}{16}$ inch in thickness and with one-finger abdominal capacity when all other conditions are good will produce 36 eggs a year; but that a fowl with a pelvic bone $\frac{5}{8}$ inch thick and with the same abdominal capacity will yield no eggs. The fact is that a hen with a large abdominal capacity and a heavy pelvic bone is distinctly a meat type, regardless of the breed to which she belongs. The relation of thickness of pelvic bone to egg capacity is further shown in the table on the following page.

It will be observed that as the thickness of the pelvic bone increases, the capacity for egg production decreases. The table on page 348 shows that a fowl having pelvic bones $\frac{1}{16}$ inch in thickness, and a four-finger capacity will produce 220 eggs, but if the pelvic bone is one inch in thickness, and the abdominal capacity is four fingers, her egg capacity is zero. In other words, she is not a layer. She is of the meat type.

3. The condition of a fowl raises or lowers egg production. Condition is shown on the breastbone of a fowl. If the breastbone at the foremost part is well covered with flesh, the condition is good, and the fowl has sufficient constitution and health to continue to consume large quantities of feed, and transform it into eggs. On the other hand, if the flesh on the prow of the breastbone is receded, thin, and emaciated, it shows poor condition, and

such a fowl cannot produce as many eggs as a fowl with a full breast, when all other factors for egg production are the same. A good layer carries some fat, for the fat of the body is used to a considerable extent to make the yolk of the egg.

THE RELATION OF THICKNESS OF PELVIC BONE AND CAPACITY TO EGG PRODUCTION WHEN CONDITION IS GOOD

THICKNESS OF PELVIC BONE	ONE-FINGER CAPACITY	TWO-FINGER CAPACITY	THREE-FINGER CAPACITY	FOUR-FINGER CAPACITY	FIVE-FINGER CAPACITY	SIX-FINGER CAPACITY
						With Nervous Temperament
$\frac{1}{16}$-inch	36	96	180	220	250	280
$\frac{1}{8}$-inch	32	87	166	205	235	265
$\frac{3}{16}$-inch	28	78	152	190	220	250
$\frac{1}{4}$-inch	24	69	138	175	205	235
$\frac{5}{16}$-inch	20	60	124	160	190	220
$\frac{6}{16}$-inch	16	57	110	145	175	205
						Slow Temperament
$\frac{7}{16}$-inch	12	42	96	130	160	190
$\frac{1}{2}$-inch	8	33	82	115	145	175
$\frac{9}{16}$-inch	4	24	68	100	130	160
$\frac{5}{8}$-inch	0	15	54	85	115	145
						Bilious Temperament
$\frac{11}{16}$-inch		6	40	70	100	130
$\frac{3}{4}$-inch		0	26	55	85	115
$\frac{13}{16}$-inch			12	40	70	100
$\frac{7}{8}$-inch			0	25	55	85
$\frac{15}{16}$-inch				10	40	70
						Lymphatic Temperament
1 inch					25	55
$1\frac{1}{14}$-inches					10	40
$1\frac{1}{8}$-inches					0	25
$1\frac{3}{16}$-inches						10
$1\frac{1}{6}$-inches						0

4. A broad back of medium length is essential for egg production, for such a back gives room for the essential organs of the body and the organs of egg production. A large heart, large di-

gestive organs and plenty of room for the egg organs are essential for a large egg yield.

Early hatched and early maturing fowls, fowls with a nervous temperament, winter layers and active fowls are better producers than fowls that have the reverse qualities. Fowls with a baggy, fat body are poor layers, for they possess the qualities which make them a meat producing type. Well-spread pelvic bones show that a fowl is laying, while pelvic bones that are close together show that the fowl is not laying at the present time.

Since the male bird is at least half of the future flock, it is highly important that he possess the characteristics which are indicative of the ability to transmit high egg producing characteristics. It is for this reason that we give the following table:

Capacity and Thickness of Pelvic Bones in a Male Bird in Relation to Egg Transmitting Qualities

Thickness of Pelvic Bones	1 Finger Capacity	$1\frac{1}{2}$ Finger Capacity	2 Finger Capacity	$2\frac{1}{2}$ Finger Capacity	3 Finger Capacity	$3\frac{1}{2}$ Finger Capacity	4 Finger Capacity
$\frac{1}{16}$-inch	84	132	180	200	235	257	280
$\frac{1}{8}$-inch	75	120	166	185	220	242	265
$\frac{3}{16}$-inch	67	109	152	171	205	227	250
$\frac{1}{4}$-inch	58	98	138	156	190	212	235
$\frac{5}{16}$-inch	50	87	124	142	175	197	220
$\frac{3}{8}$-inch	41	75	110	127	160	182	205
$\frac{7}{16}$-inch	33	65	96	113	145	167	190
$\frac{1}{2}$-inch	24	53	82	98	130	152	175
$\frac{9}{16}$-inch	16	42	68	84	115	137	160
$\frac{5}{8}$-inch	7	30	54	69	100	122	145
$\frac{11}{16}$-inch	0	19	40	55	85	107	130
$\frac{3}{4}$-inch		8	26	40	70	92	115
$\frac{13}{16}$-inch		0	12	26	50	77	100
$\frac{7}{8}$-inch			0	11	40	62	85
$\frac{15}{16}$-inch				0	25	47	70
1 inch					10	32	55
$\frac{17}{16}$-inch					0	17	40
$1\frac{1}{8}$- inches						0	25
$1\frac{3}{16}$-inches							10
$1\frac{1}{4}$- inches							0

From the preceding table it may be observed that a cock bird having a pelvic bone $\frac{1}{4}$ inch thick and $2\frac{1}{2}$-finger capacity represents a 156 egg type; but if his pelvic bone is $\frac{1}{16}$ inch thick, and his capacity is 4 fingers, then he represents a 280 egg type. Select only those cock birds which have a very thin pelvic bone and a large abdominal capacity, for they will transmit egg producing qualities.

The American egg laying contest associations have proved the following suggestions profitable in selecting hens that will produce a large number of eggs.

1. Keep the birds with large plump combs and wattles.

2. Keep hens with pale vents, pale beaks, and pale legs. They have proved to be good layers.

3. Keep the late molters.

4. Keep the pullets which mature quickly and start laying first. Those which start laying when less than 200 days old, or nearest that age, are the best layers if they have had the right care.

5. Market those which have been slow to feather or seem to lack vitality.

6. The skin of the best layers should be rather loose and flabby on the abdomen between the vent and the breastbone.

7. The pelvic bones must be thin, straight, flexible and wide apart.

8. Market the hens which are bagging behind and which have a heavy, fat, thick abdomen, which hangs below the point of the breastbone.

9. Keep the hustlers and heavy eaters that go to bed late and with full crops.

10. Birds that have long toenails, that show no signs of being workers, are usually unprofitable.

11. Choose the bird with a broad back, a long body and a stout build.

12. If a bird is not molting and yet has a small, dried-up comb, covered with a sort of whitish substance, or if the bird has thick

or crooked pelvic bones, which will be found on each side of the vent and about the point of the breastbone, she is a money loser.

Factors increasing the production and profits from poultry. — The factors aiding in increasing poultry production and which help to secure more economic profits are: (1) Hatching early; (2) Care of chicks when hatched; (3) Selling surplus cockerels; (4) Production and marketing of good eggs; (5) Preserving eggs; (6) Breeding from the best; (7) Culling out the low producers and the non-layers; (8) Good housing; (9) Feeding properly; (10) Finishing and fattening poultry; and (11) Combating the enemies of poultry.

1. *Hatching early.* — All chickens that are to become good layers should be hatched by May first or earlier. Early hatched chickens will begin laying in the fall, and with good care will lay some all winter; but late hatched fowls are small, undersized, and will not begin to lay until March or April the following spring. Early hatched chickens will begin to lay when eight or nine months old, while the late hatched ones will not lay until they are ten or twelve months old.

The fact that early hatched chickens begin to lay earlier and produce more eggs is well brought out by the following data from Bulletin 157, Maryland Station.

RELATION OF EARLY LAYING TO HIGH PRODUCTION

No. of Birds	Per Cent Laying First Egg in Month of					Total Yearly Egg Production Per Fowl
	Nov.	Dec.	Jan.	Feb.	March	
5	3.0	0.0	0.9	0.0	0.0	200 and over
56	55.4	30.4	14.2	0.0	0.0	150 to 200
109	23.9	48.6	23.9	3.6	0.0	100 to 150
54	3.7	31.1	44.4	13.0	1.4	Less than 100

This experiment shows that the fowls beginning to lay in November produced over 200 eggs the first egg laying year; and those that did not begin to lay until March laid fewer than 100 eggs

per hen. The late hatched chickens are merely boarders. Early hatched chickens are stronger and more vigorous. They grow faster and larger than late hatched chickens and are as a whole more free from disease and insect enemies. The cockerels of early hatched chickens may be disposed of at higher prices than those hatched late. For all of these reasons early hatching is mentioned as the first factor in making fowls more productive.

2. *Care of chicks when hatched* is an important factor in poultry production. There is a greater mortality of chickens during the first few weeks after they are hatched than at any other equal period. This is often due to a lack of proper care. The following points may well be put into practice. First, do not feed chicks until they are 48 to 60 hours old. Quiet, comfortable quarters in which the chick may sleep and rest are more important than anything else which may be provided. Second, keep the mother hen in a coop until the little chicks are at least two weeks old, and even after that time in the early part of the day when the grass is wet with dew, and the ground is cold. Third, provide a simple ration composed only of one or two feeds, such as oatmeal and sour milk.

FIG. 134. — The chick to the right has a full breast, body and large shanks, an excellent chick. The chick on the left has a small breast, head, neck and shanks and is in every respect an inferior chick.

3. *Selling surplus cockerels.* — Selling surplus cockerels when three or four months old is usually more profitable than keeping them longer. At this age they should ordinarily weigh from $2\frac{1}{2}$ to 3 pounds, and the prices are usually higher in early summer than later. More pounds of live poultry can be marketed with less cost when chickens are three or four months old than at any other period.

The best, most precocious, early maturing fowls, with the proper shape and color should be preserved for breeding stock. To constantly breed from late maturing fowls means a certain deterioration of the flock. See figures 134 and 135.

4. *Production and marketing of good eggs.* — A dozen good market eggs should weigh 24 to 26 ounces, be fresh, and be uniform in shape, size and color. All white eggs should be white. All brown eggs should have a uniform shade of brown. Unusually large or small eggs are undesirable. Good market eggs should be infertile, — infertile because fertile eggs spoil much more easily than infertile ones. There is at least a five per cent loss of the total egg crop because of the fact that fertile eggs are produced in the summer months. No cock birds should be permitted with the hens after the breeding season is over.

FIG. 135. — The above cockerels are the same age. The one to the left shows vigor and constitution. It had strong parents. The one to the right is weak and came from weak parents.

The preventable losses in market eggs according to Circular No. 140 of the United States Department of Agriculture is as follows:

PREVENTABLE LOSSES IN EGGS

From dirties	2.0 per cent
From breakage	2.0 per cent
From chick developed eggs	5.0 per cent
From held and shrunken eggs	5.0 per cent
From rotten eggs	2.5 per cent
From moldy and off-flavored eggs	0.5 per cent
Total	17.0 per cent

The annual loss in eggs due to preventable causes in the United States is $45,000,000, or about fifty cents' worth per person. The loss if prevented is sufficient to provide about $1,000,000 for the schools of each state.

5. *Preserving eggs.* — About 45 per cent of the egg crop is produced and put upon the market in March, April and May, as is shown by the following data quoted from the Crop Reporter, August, 1917.

Per Cent of Eggs Sold at Different Months of the Year

January	3.3 per cent	July	8.7 per cent
February	4.7 per cent	August	7.6 per cent
March	12.8 per cent	September	6.4 per cent
April	16.8 per cent	October	5.3 per cent
May	10.3 per cent	November	3.9 per cent
June	11.9 per cent	December	3.3 per cent

There is no reason why eggs should not be preserved during the period of greatest production and kept until a time when the natural and actual egg yield is smaller. If corn, wheat, rice, cotton, meat and various products are preserved, then why should eggs not be preserved?

The most convenient and the cheapest of egg preservatives for farm use is made by adding one part of water glass (sodium silicate) to nine parts of rain water, well boiled and cooled. This solution is put into ordinary stone jars. A four gallon jar is a convenient size to preserve 6 dozen eggs. This will require one pint of water glass. The top of the eggs should be covered by at least two inches of the preservative. It is advisable to cover the jar with oilcloth, or something similar, to prevent evaporation.

The jars should be kept in a place where the temperature is about 60° Fahr. or cooler. Eggs may be kept in excellent condition by this method. The shrinkage of the eggs over a period of nine months is often as little as one per cent. The results with the use of water glass are quite satisfactory and the process is comparatively inexpensive.

6. *Breeding from the best.* — Selecting and breeding from the best fowls of the flock is an important factor in making fowls more productive. In every flock it is possible to select a half dozen or dozen hens that are better than the average of the flock. These with the best cock bird should be put into a separate pen or stable during the breeding season and be used to improve the general average of the flock. Select hens that are good size, and that show feminine, motherly characteristics. Hens that show coarse, masculine qualities should not be chosen. The cut on page 356 shows the contrast between a desirable and an undesirable fowl.

Coarse features and general coarseness of a fowl indicate poor qualities for any purpose. Femininity in hens and masculinity in cocks, with constitution and vigor in both, combined with refinement, are highly desirable.

The cock bird should likewise be selected upon the qualities called for in the Standard of Perfection. He should possess constitution, early maturing qualities and bear the earmarks called for by the Hogan test.

The selection of good fowls challenges the best judgment and the experience of the best poultry raisers of our land. In order to succeed, the best thought of the best producers should be carefully put into operation.

7. *Culling out the low producers and non-layers.* — The egg production of the average hen in the United States is 64 eggs per year. There are some fowls that lay only 20 to 30 eggs, and some that do not lay at all, while others produce over 100 eggs per year. The non-layer may be eliminated by the use of the Hogan Test, selecting the pullets which begin to lay in the fall (October and November), and by choosing late molters and active fowls. The trap nest, though impractical as far as the average farmer is concerned, is, of course, the final test in showing the actual productiveness of hens.

The productiveness of the average flock may be gradually increased from year to year. If the average number of eggs can be increased by five, a good start has been made in making the

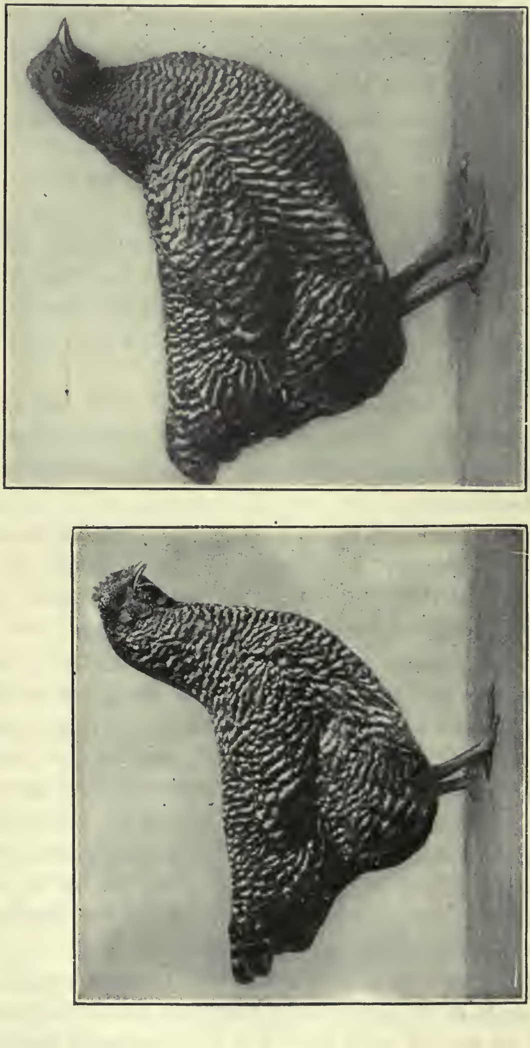


FIG. 136. — Barred Rock hens. Note the coarse features of the fowl on the left. She produced 62 eggs in one year. The hen on the right has a fine feminine head and neck, and a long capacious body. She produced 200 eggs in one year. *Form and function are closely related in poultry.*

flock pay better. If the average yield of all hens in the United States could be increased twelve eggs per hen the additional income from eggs would be $100,000,000 or about $1.00 per capita for every person in our land. Persistent work in culling out the low producers and in improving the flock will bring as good returns for the time spent as any other operation in the poultry industry.

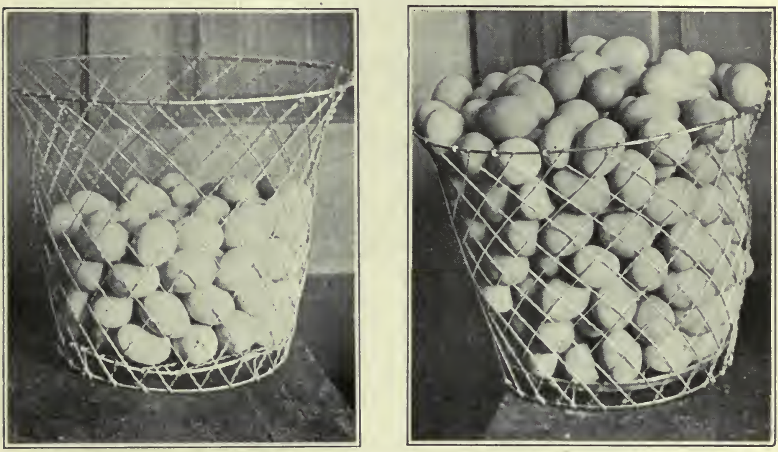


FIG. 137. — The left basket represents what the average hen produces yearly, 64 eggs. The right basket represents what she should produce yearly, 120 eggs. Five dozen eggs will scarcely pay her keep.

8. *Proper housing.* — No one could expect chickens to pay for their feed in winter unless they are housed properly. Good housing includes at least the following ten essential features.

(1) The house must furnish sufficient room. Each fowl should be allowed from three to five square feet of floor space. One hundred fowls should be given at least 400 square feet of floor space. Heavy fowls require more room than the smaller breeds. A poultry house that is to serve as a laying, roosting and living house in winter must be larger than one where additional scratching sheds are provided.

Scratching sheds are one of the prime essentials for winter

egg production. This shed should be open to the south, and be made so as to hold 8 to 12 inches of straw. Scratch grains should be fed in the straw. This provides exercise for the fowls, keeps them warm, and keeps all the organs in the best condition for a maximum egg production.

(2) The house should be dry. It should be free from atmospheric and soil moisture, for a moist house reduces the resistance of the fowls to disease.

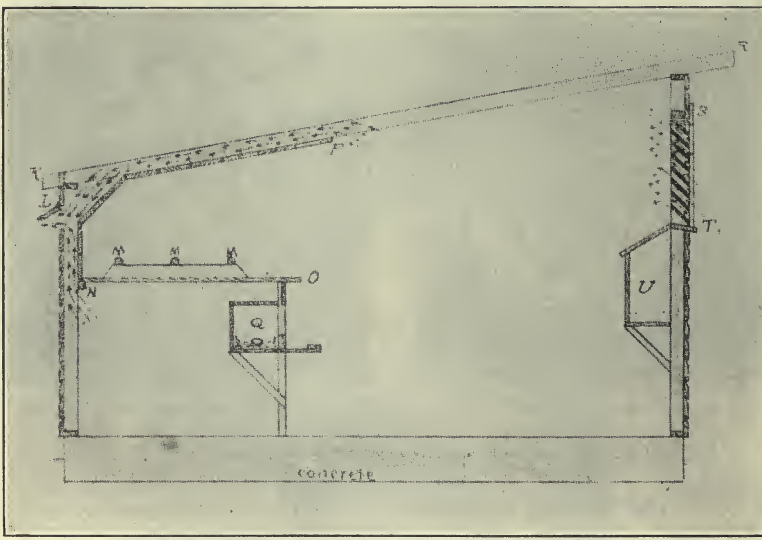
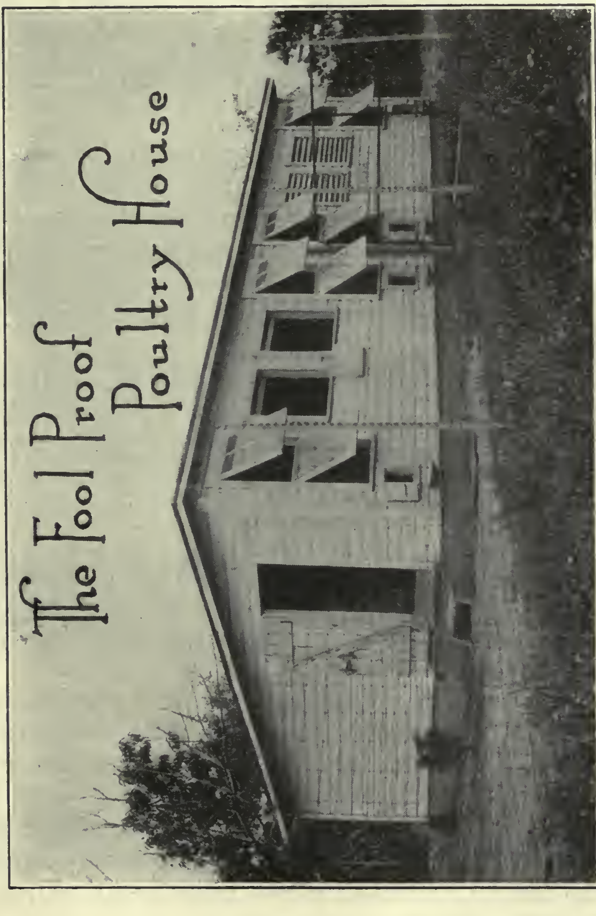


FIG. 138. — A cross section of the Fool Proof Poultry House. "M" is a roost pole, "O" is the droppings platform, "Q" is the nest underneath, "L" is the back ventilator, "U" is the bin for the grain, "S" and "T" are the front ventilators.

(3) The poultry house should be well ventilated but free from drafts. The above figure shows a cross section of the Fool Proof Poultry House. Note that direct currents are broken.

(4) Every part of the poultry house should receive sunshine during the day. Sunshine is the greatest natural insecticide we have. Windows should be tall, — two-thirds as high as the house is deep. One square foot of window space to every 14 to 15 square



Courtesy Mountain Grove Mo. Exp. Station.

FIG. 139. — The farmer's Fool Proof Poultry House. A single section is 14 feet square, which will accommodate 50 to 65 hens.

feet of floor space is sufficient and recommended by the best poultry authorities.

(5) The house should be simply constructed so that it is sanitary and easily cleaned. All interior fixtures should be light, portable and simple in construction. Cracks and openings are unpardonable. The wall should be smooth, and if made of boards, the boards should be set vertically, for boards put on vertically are more easily disinfected.

(6) All parts of the house should be convenient. Interior fixtures should be properly placed. The roost should be placed about 30 to 40 inches from the floor and be placed upon a level. Roosts placed like an ascending ladder are bad, for fowls will constantly be trying to get to the top roost, thereby pushing off other fowls. This is a common cause of several disqualifying injuries among fowls.

(7) The poultry house should be economically constructed. The cost of construction may be often reduced by using old lumber. The total cost per fowl should not exceed $1.00 under average conditions. A square house costs less than an oblong one. The roof need not be high, just high enough to be convenient for the attendant.

(8) The house should be enemy proof; that is, proof against rats and other animals. These enemies lay a heavy tax upon our poultry, and the way in which the house is constructed may prevent to a large degree this loss.

(9) A poultry house should be protected against excessive heat and excessive cold. If fowls are out of the direct wind currents in winter and in a dry house, they will suffer very little from cold. Fowl will do no good when their combs are frozen.

(10) The house should show a good coat of paint and be in good repair. All interior fixtures, doors, etc., should be in first class repair. The interior fixtures should be painted with whitewash or a coal tar preparation.

It may be well to take up poultry house construction, as regards types of foundations, floors, walls, roofs, height of houses, and

also to study the interior fixtures at this point. Refer to some poultry book, bulletin, or the Author's book, *Productive Agriculture.*

9. *Feeding properly.* — Feeding poultry well and economically is one of the most important phases of poultry production. The two topics of feeding growing chickens and feeding for egg production will be discussed.

(1) Feeding growing chicks. They should not be fed for 48 to 60 hours after hatching, and then a single simple food consisting of boiled eggs and some milk or oatmeal and sour milk should be given. After that cracked corn and a dry mash made of a small amount of meat scraps with bran should be fed. One part of the meat product added to about nine or ten parts of bran makes an excellent ration. Plenty of sour milk is always an excellent supplementary feed with a grain ration to make chickens grow. Some mineral matter in the form of oyster shell, and other small grit adds to the usefulness of the rations.

(2) Feeding for eggs. Two-thirds or more of the profits of the average flock come from the sale of eggs ($80.57), and one-third from the sale of chickens ($31.82). Often in back yard poultry production scarcely any attention is given to any product from poultry except eggs. How to feed for eggs is the big question.

In order to feed for eggs we must know the composition of eggs. It is as follows:

PERCENTAGE COMPOSITION OF EGGS AND FOWL'S BODY

	WATER	FAT	SUGAR	PROTEIN	ASH
Milk (for comparison) .	87	3.8	4.98	3.5	0.7
Eggs (whole)	66.7	8.9	0.0	12.0	12.2
Eggs (edible part) .	74	10.5	0.0	14.9	0.8
Hen's body (on foot) .	56	18.8	0.0	21.6	3.8

The parts of an egg are the yolk, the white and the shell. The yolk is composed mainly of fat; the white is almost pure albu-

men; and the shell is 90 per cent lime. Each part of the egg is made in a different part of the egg laying organs. The yolk is made in the ovary, — and all the yolks that are ever to be produced are found in embryonic form in the ovary when the chick is five or six months old, hence the value of feeding during the early part of the chick's life. The number of yolks found in the ovary

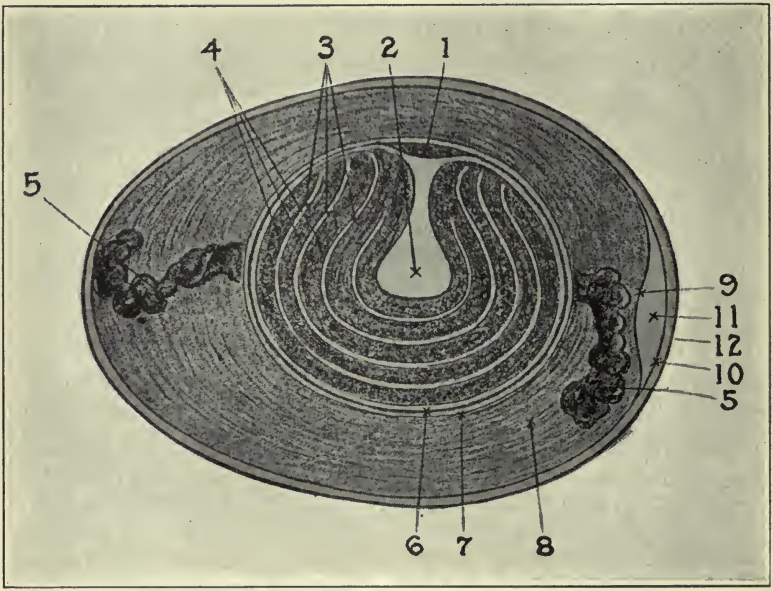


FIG. 140. — The diagram of a cross section of the egg when lengthwise. 1. Germinal disk. 2. Central white yolk. 3. Concentrated white layers surrounding the yellow yolk. 4. Yellow yolk. 5. Chalazae. 6. Vitelline membrane. 7. A thick albuminous layer which envelops the yolk. 8. The albumen. 9. Interior shell membrane. 10. Exterior shell membrane. 11. Air chamber. 12. Shell.

range from 1500 to 3600, more than can ever be matured. The white of the egg is made in the upper part of the oviduct, requiring from six to eight hours. The white of the egg has three distinct layers, each one containing more water as we pass from the inner to the outer layer. The shell of the egg is made in 12 to 24 hours in the lower part of the oviduct.

A balanced ration for egg production furnishes feed so that an equal number of yolks, whites and shells may be made. To supply feed so that 100 yolks might be produced, but only 50 whites and 50 shells, limits the production to 50 eggs. Such a feed would

FIG. 141. — Photograph of the egg organs to show the sections when different parts of the egg are made.

not be a balanced ration. Feeding an unbalanced ration, such as the suggested one, is very expensive, for most of the feed is used for maintenance and not for production. Professor C. T. Patterson of the Mountain Grove Experiment Station, Missouri, has worked out a plan for balancing rations for egg production. He states that 100 pounds of the following feeds will provide the ingredients to make yolks and whites as indicated.

Number of Yolks and Whites That May Be Built from 100 Pounds of Different Feeds

Feed	Yolks	Whites
Corn	255	134
Wheat	243	182
Oats	195	155
Bran	155	205
Shorts	205	220
Alfalfa hay	46	67
Meat scraps	106	1107
Fresh cut bone	196	336
Whole milk	44	60
Skim-milk	22	52
Buttermilk	22	65
Mangel beets	19	18

The table assumes that one pound of carbohydrates will make $3\frac{1}{2}$ yolks, and one pound of protein will make $16\frac{2}{3}$ whites. This is above body maintenance.

The following shows a balanced and an unbalanced ration based upon the above table.

An Unbalanced and a Balanced Ration

Unbalanced			Balanced		
Feed	Yolks	Whites	Feed	Yolks	Whites
100 lb. corn	255	134	120 lb. corn	255	234
100 lb. wheat	243	182	100 lb. wheat	243	182
20 lb. oats	39	31	20 lb. oats	39	31
20 lb. bran	31	41	20 lb. bran	31	41
20 lb shorts	41	44	20 lb. shorts	41	44
20 lb. oatmeal	50	50	20 lb. oatmeal	50	29
			20 lb. meat scraps	20	221
Totals	659	461	Totals	679	682

And a simple ration which can be used by every feeder of poultry if all the feeds in the above ration cannot be provided may be as follows:

A BALANCED RATION FOR EGG PRODUCTION

FEED	YOLKS	WHITES
Corn, 100 pounds	255	134
Meat scraps, 10 pounds	10	110
Skim-milk	23	52
Totals	287	296

Although this ration is not quite balanced, it is near enough balanced for practical purposes.

The Connecticut, Massachusetts, New Jersey and Cornell Poultry Experiment and Egg Laying Contest Stations have adopted the following rations:

(1) The grain scratch ration is to consist of:

500 pounds corn. 100 pounds feed wheat. 200 pounds barley. 200 pounds heavy oats.	This part of ration to contain not less than 10 per cent protein, 68 per cent carbohydrate and 4 per cent fat.

(2) The mash ration is to consist of:

100 pounds wheat bran. 100 pounds wheat middlings. 100 pounds corn meal. 100 pounds gluten feed. 100 pounds ground heavy oats. 100 pounds meat scraps.	The mash must contain 20% protein, 58% carbohydrates and 5% fat. Skim-milk or buttermilk may be used as a substitute for the meat scraps.

The importance of a meat product in the ration for poultry is shown in the above rations used in the egg laying contests. Almost every experiment station has some definite data on the value of meat or milk products in egg production. Inquire from your station regarding the value of meat products for egg production.

Another valuable guide to feeding poultry is to follow the requirements set by the following: [1]

FEED REQUIREMENTS OF CHICKENS PER DAY PER 100 POUNDS

	Dry Matter Pound	Protein Pound	Carbohydrates Pound	Fats Pound	Nutritive Ratio
Growing chicks, 1st 2 weeks	10.1	2.00	7.20	0.4	1 : 4.1
Growing chicks, 2 to 4 weeks	9.6	2.2	6.20	0.50	1 : 3.4
Growing chicks, 8 to 10 weeks	6.4	1.20	4.40	0.30	1 : 4.3
Hens, maintenance only	2.7	0.40	2.00	0.20	1 : 6.2
Hens for egg production	3.3	0.65	2.25	0.20	1 : 4.2

It will be worth while to balance a few rations in accordance with the above requirements. A growing ration may consist of 5 pounds cracked corn, 5 pounds oatmeal, 1 pound meat scraps and 10 pounds skim-milk.

Winter eggs can be secured only from early hatched fowls, good housing, good feeding and protection from cold by a scratching shed.

10. *Finishing and fattening poultry.* — The common practice of marketing poultry is to go some morning to the poultry house and select the sorriest looking fowls in age, appearance and degree of fatness, catch them, and send them to market. Cattle and hogs were sold somewhat similarly in pioneer days. Now all live stock except poultry is fattened and finished before it is put upon the market. Poultry is still marketed in reverse order from that in which it is fit for the market. It is the purpose of this section merely to suggest that fattening poultry for the market usually brings good profits.

Fattening fowls increases the weight, improves the quality and elevates the selling price of every pound of live weight sold. According to Jordan [2] large fowls, small fowls and broilers will

[1] Lewis, *Productive Poultry Husbandry.*

[2] *Feeding of Farm Animals.*

produce a gain of 19.6, 22.0 and 28.7 pounds respectively with 100 pounds of digestible organic matter in the ration. This compares well with th efficiency of other types of live stock in making gains, and usually poultry is as high priced on foot as any other type of live stock.

The method of fattening poultry is simple. The fowls are penned up for about 10 to 16 days, and given slightly more than the usual amount of feed. The additional feed should contain fattening nutrients. The average fowl will fatten easily. A few fowls, not of the meat type, will refuse to fatten. The fattening of poultry by the poultry keeper is profitable; it is likewise profitable to the average farmer. Friers, broilers and roasters may be fattened as well as old fowls.

11. *Combating the enemies of poultry.* — An eleventh important factor in making poultry more profitable is to prevent, combat and eradicate the enemies of poultry. "An ounce of prevention beats a pound of cure." Many of the enemies may be defeated by breeding on y from vigorous stock, — stock that is from one and a half to two years of age, and possesses the constitution and vitality observed in the best of fowls. Late hatched, small sized fowls succumb to disease much more readily than do earlier hatched, well-matured, good sized fowls. Clean housing, clean feeding, feeding well and a balanced ration, and providing plenty of exercise for the fowls helps to maintain good health conditions. The house should be cleaned frequently, and the interior walls painted with whitewash. This disinfects the wall. Sunshine, too, helps in keeping the house sanitary. A few of the more common enemies of poultry will be discussed in the following paragraphs.

Lice and *mites* handicap greatly the poultry industry. They affect growing chicks mostly, but old fowls are also much hindered in their capacity to do good work. Lice remain on the bodies of the fowls day and night. They may be combated to some extent by providing a dust bath containing about equal parts of wood ashes, clay and sand mixed with about three to four per cent kero-

sene. The bodies of fowls may be dusted with Persian insect powder, or be greased with equal parts of kerosene and lard. *Mites* may be killed by sprinkling kerosene over the interior of the house or by burning sulphur in the house. Mites get off the fowls during the day, and the remedies above suggested may be given during the daytime.

Scaly legs are caused by mites which live under the scales of the shanks of fowls. They cause the shanks to become enlarged. The remedy lies in removing the cause. Stand the fowl in a solution of equal parts of kerosene and linseed oil well mixed. Kerosene kills the mite. Two or three treatments about ten days apart are usually sufficient.

Roup is a contagious disease corresponding to a bad cold. In aggravated cases the face of the fowl becomes swollen and appears like a tumor. Often one or both eyes may swell shut. There is a discharge from the nostrils. To cure the roup, press the cheesy matter out of the tumor by pressing it toward the nostril, and dip the part affected in kerosene. In bad cases of roup it is advisable to kill the fowl. A sufficient quantity of permanganate of potash added to the drinking water to color it a deep red is a preventive as well as a cure for roup.

Limber neck is caused by fowls eating decomposed meat. The ptomaine poisoning causes paralysis of the neck, and all control of the neck is lost. Treatment of fowls is usually ineffective, although a teaspoonful of castor oil may relieve the disease. All dead fowls should be burned.

Bumble foot is caused by fowls alighting on hard surfaced floors which bruise the bottom of the foot, and this continued causes bumble foot. Remove the cause by lowering the roosts. Cut the enlargement out and cover the scar with vaseline.

Gapes is caused by small worms getting into the trachea or windpipe of chicks usually when they are from two to six weeks old. All coops should be cleaned and disinfected with lime or a five per cent carbolic acid solution. The worms may be removed by inserting a feather dipped in turpentine into the trachea of the

chick. The oil will dislodge the worms, and they will be expelled by sneezing.

Apoplexy is due to fowls being too fat. This causes high blood pressure, which breaks the blood vessels in the head. The fowls are attacked suddenly and death often occurs just as suddenly. Fowls are found dead under the perches, or occasionally under bushes where they seek shade from the hot summer sun.

White diarrhea is known to all poultry raisers, and its symptoms are well known and are shown in the following cut.

FIG. 142.—Ten day old White Leghorn chicks, showing symptoms of white diarrhea.

Many different remedies for white diarrhea have been tried, but none have helped in curing the disease. Preventive measures, such as using vigorous, healthy breeding stock, sanitary housing and good feeding help to a great extent in preventing the disease. Feeding sour milk for the first two weeks is a good preventive. All chicks having white diarrhea should be killed and burned.

Summary. — The poultry industry is among the most important, and is more generally engaged in than any other line of animal husbandry. The advantages of poultry raising are many, and it is for this reason that the industry is very important and is carried on generally, not only on the farm, but in the cities as well. There are many classes, breeds and varieties of fowls. The shape, size and color markings of fowls are sufficiently varied that the fancies of every lover of chickens may be satisfied. All pure

bred fowls have been developed for a specific purpose, and for that reason have several advantages over scrubs or mongrels.

It is a well-established fact that heavy egg producers have an egg type, which is conducive to egg production. The egg type of fowl may be found in any breed. It possesses a large abdominal capacity, a thin pelvic bone and a full breast; and usually has a long and wide back; and has a disposition which is conducive to high egg yield. It is hoped that the egg yield of fowls will be increased from the present average, which is 64 eggs per year.

The factors which will help to increase poultry production are: early hatching, care of chicks when hatched, selling surplus cockerels, producing and marketing good eggs, preservation of eggs, breeding from the best, culling out the low producers, good housing, feeding properly, finishing fowls for the market and combating the enemies of poultry. These and other factors help in securing maximum production, and must be put into operation if poultry and poultry products are to be produced at the least cost and the greatest profit.

QUESTIONS

1. Compare the production of poultry with that of other farm animals.
2. What are the advantages of the poultry industry?
3. Define class, breed, and type as applied to poultry.
4. What are the advantages of pure bred fowls?
5. Describe the characteristics of a good fowl.
6. What are the physical features which cause a fowl to belong to the egg type? Meat type?
7. A fowl that has a 175-egg capacity has what finger capacity, and how thick a pelvic bone?
8. Name the factors that will help to increase the profits from poultry.
9. Balance a good egg ration.
10. Name three poultry diseases you have had experience with. How did you combat the disease?

PROBLEMS

1. Report on the book, *The Standard of Perfection.*
2. Report on the market classes of eggs.
3. Report on two poultry bulletins.
4. Discuss the interior fixtures of a poultry house.

REFERENCES

The Standard of Perfection.
Lewis, Productive Poultry Husbandry.
Lippincott, Poultry Production.
Hogan, The Call of the Hen.

THE ADDRESSES OF A FEW POULTRY BREEDERS' ASSOCIATIONS

American Barred Plymouth Rock Club, C. J. Behn, Sec., Chicago, Ill, 7537 S. Sangamon St.
American White Plymouth Rock Club, M. L. Chapman, Browns Mills, N. J.
National White Wyandotte Club, S. C. Bobble, New Cumberland, Pennsylvania.
National Black Langshan Club, H. A. Reasner, Juliette, Indiana.
American S. C. Brown Leghorn Club, H. V. Tormohlen, Portland, Ind.
Northern Orpington Club, Mrs. John Kruse, Minneapolis, Minn., 127 Russel Ave.

SECTION III. SOILS

CHAPTER XXII

AGENCIES IN THE SOIL FORMING PROCESS

Origin of soils. — A long, long time before man appeared, the earth was a molten, gaseous mass, "without form and void" according to Biblical story, but it was gradually cooling off and becoming harder. This cooling, gaseous mass was composed of water and the various rocks now found in the earth. As it cooled it solidified. The process of solidification caused the earth to shrink. This is the reason the earth's surface is elevated in some parts and depressed in others. Mountains, hills and valleys are the result of the changing of the earth from a molten mass to a solid mass.

This solid mass, although broken in many places by the shrinking of the earth, was nothing but fire burned rock. Sandstones of various kinds, fine, medium and coarse, limestone, granite, quartz and other kinds of rocks were to make the chief foundation portion of our soil. The breaking down or disintegration of the sandstones is responsible for our sandy soils. Clay soils are due to the decomposition of feldspar and mica, both of which are a type of granite rock. Limestone soils are made largely from limestone, and generally contain small quantities of silica (sand) and iron compounds. The iron compounds give clay soils their reddish and yellowish color. The kind of soil depends to a large extent upon the kind of rock from which it was originally made.

It is the purpose of this chapter to discuss the agencies that originally aided in making the soil and the value of these agencies

in the building of the soil to-day. The chief agencies in the formation of the soil are (1) water; (2) plants; (3) animals; (4) winds; and (5) weathering.

Water, an agency in forming soils. — Water in the form of a liquid and a solid is the most potent agency in soil formation. The various kinds of streams, from rivulet to river and ocean current, are constantly changing the surface of the earth. We are told by geologists that the bed of the ocean is becoming more level daily because of the movement of water, which carries over sediment. Likewise, the earth is being leveled. Streams of water moving over the land produce much friction on the surface over which they are traveling. This friction and the dissolving qualities of water break up and wear down rock particles. Many acres of land have been formed by alluvial deposits. In fact, all lands along streams, bottom lands, the coastal plains, the soils at the foot of mountains and hills have been formed to a large extent by moving water. The hillsides were impoverished, and the bottoms were enriched. The impoverishment of hillsides should be prevented by systems of farming and by farm management that prevent soil washing.

FIG. 143. — Cliffs of rocks, showing the effects of wave action.

The tides of the ocean, the waves of the lake or pond, are constantly changing the contour of the coast or land line. The opposite picture well illustrates the observations made by every one who has seen a cliff along the water's edge.

The waves of water driven by the winds erode and break down the rock of the cliff.

Water percolating through the soil and through the rocks dissolves and helps to disintegrate the rocks and rock particles of the

soil. The cement that binds together the particles of sand of the sandstone is dissolved, and the rock crumbles into a sandy mass. Some of the limestone effervesces in the presence of water, dissolves, and forms a powdery mass. All rocks are affected more or less by percolating water.

Vegetation is aided in its rounds of decay and putrefaction by the presence of a proper amount of water. When plants are placed in a dry place or in water they decompose very slowly, but at the surface of the earth a proper amount of water is usually present, so that the plant that was grown this season may decompose and change its organized system into a disorganized form. Thus the plant of one generation may use the plant foods the plant of the preceding generation has stored in its own body. What a wonderful friend water is to man! Three-fourths of the earth's surface is covered by water; seventy to ninety per cent of green vegetable life is composed of water; about fifty per cent of the bodies of animals is composed of water; and the rounds or cycles of life are aided by water.

Water with changing temperatures is a wonderful agent in the formation of the soil, and has been since the beginning of geologic times. Freezing water, in cracks of rocks, between soil particles, and wherever found, cleaves the most tenacious and hardest of rocks. Water expands about one-twelfth upon freezing. It is for this reason that a bottle or pipe bursts when the water content freezes. Rocks are broken asunder by this powerful agent, and soils are formed. Not only should we think of freezing water in breaking up the original rocks, but we should also think of its ameliorating effects upon all soil that is frozen through and through every winter since time began. Farmers rather welcome severe freezing winters. A thorough freezing of the water in the soil is like the addition of a small quantity of manure to the land.

Glaciers many years ago (probably 5000–10,000) were a great factor in forming the soil. Some of the glaciers were large. These slow-moving glaciers mashed and ground the rocks and carried a lot of vegetation and débris with them, — all pulverized, — form-

ing soil. Some of the best soil of the world is of glacial and alluvial formation. The following map shows the region of the United States formed by glacier.

FIG. 144. — Map of North America showing the area covered by ice sheets and the extent of glacial formed soils.

Plants as agencies in forming soils. — The effects of plants on soils are of three kinds; namely, physical, chemical and bacteriological. *Plants aid in forming the soil physically.* In the formation of the earth in the beginning, plants affected to a large extent the parent rock, but plants at the present affect the soil itself to a greater extent. In the beginning plants cleaved rocks and broke them apart, and this method of forming soil is still going on.

Rocks and cliffs have been separated, sidewalks have been torn up, and stone walls have been turned over by the roots of growing plants. Marks have been left by growing lichens upon the hardest tombstones found in the cemetery. Trees with their deep penetrating roots, the grasses with their shallow growing roots, the legumes with their nodule forming roots — all have had, and will continue to have, a wonderful physical effect upon the mother earth.

Not only in cleaving the rocks and soils have the plants had a wonderful effect in soil formation, but the roots, the stems and the leaves upon decomposition have added organic matter to the soil. This organic matter makes the humus, and humus is a large part of the soil, physically speaking. Beat into sand particles a fifty-pound sandstone rock, and powder into dust a fifty-pound limestone rock, and add to this fifty pounds of organic matter; mix these three components thoroughly and you will have a fairly good soil, — not subsoil, but soil. For as soon as you added organic matter to the beaten sandstone and pulverized limestone, you converted into soil materials out of which subsoils are made. Soils that contain much organic matter are lighter and much more easily worked than when the humus is lacking. This is a common observation of every farmer. If you want a soil to plow easily, get a lot of organic matter into it — this gives it lightness and such a fine tilth that it is easily workable.

Thus plants both in the process of growth and in the process of decay change the physical characteristics of soil. Their growing roots cleave and crumble the soil; and their decaying bodies make it mellow and light. But the good done by their decay does not end here.

Chemically, the soil is enriched by decaying organic matter. Every plant that decays adds to the soil all the elements that were needed for its growth. The composition of the corn plant follows:[1]

[1] Vivian, *First Principles of Soil Fertility*.

- Corn Plant 1000 pounds
  - Water 793
    - Hydrogen 88.1
    - Oxygen 704.9
  - Dry matter 207
    - Organic matter 195
      - Protein 18
      - Fat 5
      - Fiber 50
      - Carbohydrates 122
        - Nitrogen 2.9
        - Carbon 90.5
        - Oxygen 88.9
        - Hydrogen 12.7
    -
      - Chlorine 0.4
      - Potash 4.0
      - Phosphoric acid 1.2
      - Lime 1.6
      - Magnesia 1.4
      - Iron oxide 0.3
      - Sulphuric acid 0.3
      - Soda 0.4
      - Silica 2.4

Although plants do not add the ingredients in the same proportion, because different plants have different compositions, yet in general they add the ingredients they need in their own growth.

The decaying organic matter forms humic (humus) acids. If a pound each of soil, water and manure (organic matter) are mixed together, the chemical composition of the water soon changes. The water and the ingredients in the organic matter mix, and this mixture acts more vigorously upon the hard rocks than water does alone. The discolored water takes out some of the mineral compounds in the rock soil particles and prepares them into a soluble form for plant growth. The chemical changes in the soil due to the presence of humus are highly essential in making plant foods available for further plant growth.

Cultivation, fallowing the soil and dry hot weather are conducive to an excessive loss of humus in the soil. Every precaution in the way of keeping a soil mulch, covering the soil with green manure crops, and preventing it from drying out should be employed in conserving humus, the most wonderful of all plant foods.

Peaty or marsh soils made by decaying vegetation in ponds and lakes is composed of about twenty per cent of humus. Arid

lands often have less than two per cent and the average field in the corn belt has about five per cent humus. A few years of careless soil management may reduce this chemically important plant food materially, so that the productive acreage capacity of the land is reduced from five to ten dollars.

Bacteria, which are very necessary to plant growth, feed upon the organic matter in the soil. It has been known for a number of

FIG. 145. — Bacteria have formed the nodules on the roots of the legume plant.

years that clover, alfalfa, soy beans, cowpeas and other legumes do not do well in some soils. It was later discovered that as soon as the soil is inoculated with proper bacteria the plants thrive. The nodules on the legumes are caused by specific bacteria. The above figure shows the nodules and the bacteria, magnified, which caused them.

From three to fifteen million bacteria have been found in a gram of soil. They live to the greatest extent in the surface foot, where plant foods in the form of organic matter exist. The changes wrought upon organic matter by the bacteria in the soil are very important, — and the function of these little organisms in the soil cannot be overemphasized. Hence the proper condition conducive to their growth should be rationally guarded. The conditions for their growth are: (1) Food; (2) Proper temperature; (3) Proper amount of moisture; (4) A proper amount of air. Plants then are important agents physically, chemically and bacteriologically in the formation of soil.

Animals, an agency in forming soils. — Earthworms consume soil for their food. The soil thus used is broken down and disintegrated to a considerable extent. The openings they leave in the soil affect the physical condition of the soil. Darwin estimated that earthworms carry about one inch of soil to the surface of the ground in England annually. The work that earthworms do helps materially in improving the soil. Ants, gophers, ground squirrels and badgers improve the soils that they dig up.

The manure voided by animals is one of the largest factors in keeping up soil fertility. The proper care of manure should be considered for its importance in soil formation. Much soil fertility is shipped to the cities by way of livestock. The return of the waste materials in the form of commercial fertilizers must sooner or later become a practice if our land fertility is to be maintained. The slaughterhouses must in the future become more serviceable in returning fertility to the farmers at reasonable prices, for after all, it is a mutual service.

Wind, an agency in forming soils. — Wind formed soils are important in some sections of the United States. In some of the Western States the winds have taken away the depth of the plowed soil, and carried the soil elsewhere. Cover crops are often grown to protect the soils from the winds. Loessial or wind formed soils are quite extensively found in some sections of the United States, and are an important soil type.

Weathering of soils. — The effects of weathering have been discussed to some extent in this chapter. In addition we should mention the heat of the summer and the cold of the winter and ever changing temperature from season to season, and from day to day, as important factors in forming soils. The weathered rocks may be seen along the roadside. The crumbling banks along roads and streams are an evidence of weathering. Rainfall aids in the weathering process. It is an interesting study to examine an outcropping sandstone to see the effects of weathering.

Summary. — The chief agencies in the formation of the soil are water, plants, animals, winds and the weathering processes. We should look upon most of these agencies as our helpers. However, running water and winds may do a lot of damage to the soil. It is important that we know how to make the best use of plants, animals and weather conditions in order that they may render us more service in maintaining and improving soil fertility.

QUESTIONS

1. Name the soil forming agencies.
2. Describe the action of water in its various ways in forming soils.
3. Discuss the agencies causing the breaking down and decay of organic matter.
4. Discuss animals as they assist in forming the soil.
5. What kinds of rocks are excellent materials for making fertile soils?

PROBLEMS

1. Report upon the glacial period and upon its value in forming soils.
2. Find an example of the effects of weathering in your locality.

REFERENCES

Whitson and Walster, Soils and Soil Fertility.
Vivian, First Principles of Soil Fertility.
Burkett, Soils.

CHAPTER XXIII

CLASSIFICATION OF SOILS ACCORDING TO FORMATION

Two classes of soils. — Soils may be classified according to the way they were formed. Those that have not been moved, but were formed from the rock beneath and the vegetable matter which has been added, are called sedentary soils. And those which have been moved are called transported soils. Level upland soils usually belong to the first class; soils along streams are transported soils because they were carried there by water.

These two groups of soils divide themselves into the following classes in accordance with the specific way they were formed.

Sedentary Soils		Residual Cumulose
Transported Soils	Gravity formed soils	Colluvial
	Water formed soils	Alluvial Marine Lacustrine
	Ice formed soils	Glacial
	Wind formed soils	Æolian Loessial

Sedentary soils of both classes, residual and cumulose, will be discussed first. *Residual soils* were formed by the weathering processes from the rock or rocks underlying them. Hilgard calls them sedentary, residual or "soils in place." The level uplands, usually residual soils, are often of a sandstone or limestone formation. The parent rock or rocks determine almost wholly the make-up of a residual soil. Although the residual soils lack the fertility found in the rich alluvial soils, they bring fair yields in grass, wheat, oats, corn and the legumes.

Cumulose soils are soils formed in shallow lakes, ponds and marshy places where an abundance of vegetation grows in the

water and finally accumulates to such an extent that the water in the marsh, pond, or lake is driven out and soil occupies the place. The accumulation from year to year forms the cumulose soil. The cumulose soils are very different in formation and composition from the residual soils. The parent of the residual soil was the rock beneath; the parent of the cumulose soil is vegetation.

Muck and peat soils are the two classes of cumulose soils. The peat soils[1] contain from 40 to 85 per cent decayed plant matter. Residual soils usually contain from five to eight per cent organic matter. The organic matter forming peat soils, when sufficiently pressed, forms coal beds. Peat soils are black in color and are very fertile. They are rich in nitrogen and lack potash and phosphorus. Muck and peat soils, found in low places usually, are extremely valuable when drained.

Residual and cumulose soils, formed mainly from rocks and vegetation respectively, are sedentary soils. The former is composed of 90 to 95 per cent rock and 5 to 10 per cent decayed organic matter. The latter is made up of 40 to 85 per cent organic matter and 15 to 60 per cent rock material. Some of the silt, clay and sandy soils belong to the residual class of soils; while peaty and muck soils belong to the cumulose class.

Transported soils. — The soils formed by gravity, water, ice and wind are known as transported soils.

Colluvial soils are gravity formed soils along hillsides, cliffs and mountains where the soil is constantly moving down the slope by gravity. The soil thus formed is colluvial soil.

Water formed soils comprise three classes; namely, alluvial, marine, and lacustrine. *Alluvial deposits* of soil are common along streams. The soils so formed were carried there by the flowing water. Ancient Egypt was much enriched from year to year by the overflowing of the Nile, which left a rich deposit of soil sediment every time it overflowed the land. A vast acreage of land along the Mississippi (and other streams) was carried

[1] Illinois Bulletin, No. 123.

there by the flowing water. Some of the alluvial soils need drainage, and when properly drained make fertile and tillable land. Alluvial soils are very fertile, partly because decayed organic matter is light and is easily carried by water. Slow flowing water will carry clay; water flowing at the rate of twenty-four feet per second will carry rocks as large as a hen's egg. When flowing water deposits the particles it carries, they are laid down in the following order: rocks, coarse sand, medium sand, fine sand, silt, clay and organic matter.

Marine soils are those soils which have been carried out into the ocean at the mouth of a river and along coast lines. These soils, owing to the fact that they themselves are rising or the ocean is sinking, finally rise above the level of the sea. Long Island, parts of Florida and the Gulf Coast plain have been formed in this manner. The marine soils are generally fertile, and are adapted to a varied agriculture. Vegetables, fruits, forage crops, and corn, oats, cotton and rice thrive upon the marine soils, when they are properly drained.

Lacustrine soils are those soils which have been carried into lakes, ponds, etc. Many lakes have a narrow fringe of soil which has been carried there and while under the water for some time has subsequently been raised above the water by additional deposits. Lacustrine and marine soils are similar in their formation. The only difference is in their location.

Ice formed or *glacial formed* soils were discussed in the previous chapter and need but a passing word here. For the area once covered by glaciers see the map on page 375. The moving glaciers, carrying tons upon tons of material, ground the rocks they carried into the finest of soil particles, and in the area of the "glacial drift" we find clay and silt loams mainly. The glacial soils are like the rocks from which they were made, plus the organic matter since grown and left upon the soil by decay. The glacial formed soils are adapted to general farming, and some of the best soils of Minnesota, Michigan, Iowa, Illinois and North Missouri are of glacial formation. Lyon, Fippin and Buckman say,

in their book on soils, "The Ice Age was certainly not in vain, so far as the production of fertile soils is concerned."

Æolian or wind formed soils cover large areas of the Western States where the dry arid soils are often driven for miles by the wind and then deposited. A type of soil called "loess soil" which extends in irregular sections from Ohio to Nebraska, and from Wisconsin on the north to Mississippi on the south, although it was not definitely known how it was formed, was more than likely formed by glacial, water and wind action. The loess soils are fine fruit producing soils because of their porous physical properties, and also because of their rich chemical composition. Agriculturally, the loess soils are very productive and valuable.

Summary. — According to the formation of soils there are two large classes; namely, sedentary and transported. *Sedentary* soils are either residual or cumulose. Residual soils are generally sandy, limestone, black loam soils. Cumulose soils are either muck or peaty soils. *Transported* soils are soils that have been moved by gravity, water, ice, or wind. Transported soils are usually rich, fertile soils, and the alluvial, glacial, or loess soils are among the richest soils we have. If it is possible several classes of these soils should be studied in a first hand laboratory way.

QUESTIONS

1. What is a residual soil? A transported soil?
2. Define alluvial, marine, and lacustrine soils.
3. What is a glacial and an æolian soil?
4. How were the soils formed in your locality?
5. What classes of soils are now being formed in your locality?

PROBLEM

Report from other sources upon the main points of this chapter.

REFERENCES

Whitson and Walster, Soils and Soil Fertility.
Vivian, First Principles of Soil Fertility.
Lyon, Fippin and Buckman, Soils, Their Properties and Management.
Burkett, Soils.

CHAPTER XXIV

TEXTURE OF SOILS [1]

Meaning of soil texture. — The term "soil texture" refers to the size of the soil particles. Sandy soils are composed of rather large particles, but clay soils are made up of small particles. The soil particles decrease in size through fine gravel, coarse sand, medium sand, fine sand, very fine sand, silt and clay. The Bureau of Soils of the United States Department of Agriculture has given us the following measurements and comparative sizes of soil particles.

MECHANICAL ANALYSIS OF SOILS

	DIAMETER MEASUREMENT	RELATIVE SIZE
Fine gravel . . .	1 to 2 millimeters	
Coarse sand . .	1 to 0.5 millimeter	
Medium sand . .	0.5 to 0.25 millimeter	
Fine sand . . .	0.25 to 0.10 millimeter	
Very fine sand. .	0.10 to 0.05 millimeter	
Silt	0.05 to 0.005 millimeter	
Clay	0.005 to 0.00 millimeter	

[1] For suggestive laboratory exercises which should be done by pupils turn to the Gehrs and James laboratory manual entitled *One Hundred Exercises in Agriculture.*

From the preceding and from examination of soil particles it will be seen that clay particles are very, very small, and that coarse sand particles are very large. If each particle were taken between thumb and finger, the sand particle could be readily felt, but the clay particle is so small that it could not be felt. The diameter of the clay particle is to the diameter of the coarser sand particle as one is to one hundred, or, if shown in another way, as the following short line is to the long line.

Clay
Sand

In other words it would require one hundred clay particles laid side by side to equal the diameter of a coarse sand particle. Since the volumes of spheres are to each other as the cubes of their diameters (.005 to .5mm.) or in this instance, as $1^3 : 100^3$, the coarser sand particles have one million times the volume of the small clay particles. In other words, a cubic foot of clay contains one million times as many particles as an equal volume of coarse sand.

The surface area of soil particles should also be comprehended in a general way because the surface area of soils as exposed by the soil particles influences wonderfully the processes in the soil. It has been estimated by our best soil physicists that the area of the soil particles, assuming that all particles are spherical, is for each cubic foot as follows:

Surface of Soil Particles per Cubic Foot

	Square Feet
Sandy soil	40,000
Sandy loam	65,000
Silt loam	100,000
Clay	150,000

Clay has almost four times as much surface area as does a sandy soil. What effect does this variation in surface area of soils have upon the water holding capacity, surface area exposed to

growing roots, aëration of the soil and chemical reaction of the soil? This question we will try to answer.

Importance of soil texture. — The water holding capacity of one hundred pounds each of three different soils is as follows:

WATER HOLDING CAPACITY OF SOILS

100 pounds coarse sand	22 lb. water
100 pounds clay	55 lb. water
100 pounds humus	143 lb. water

It is evident that it requires two and one-half times as much water to wet clay soil as to wet a sandy soil. In other words, a rain penetrating a clay soil one inch will penetrate a coarse sandy soil two and one-half inches. However, the clay soil will appear much wetter than the sandy soil. Water passes through a clay soil so slowly that the top layer soon becomes saturated to such an extent that the surface begins to wash. The following apparatus used as indicated will illustrate percolation of water through different kinds of soils.

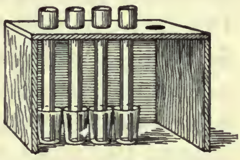


FIG. 146. — Three percolators filled with sand, loam and clay respectively. Used to determine the rate of percolation in different soils.

Clay soil exposes much more surface to the growing roots than does a sandy soil. This is an advantage when all other points are the same. That is one reason why we work soils down to a fine tilth, so that a maximum amount of soil surface be exposed to the growing roots. But clay soils are usually wet soils, and wet soils are cold soils and therefore cannot be tilled early enough to make them good truck soils.

The amount of air in clay soils would be more, provided the soil were dry; but since clay soils hold the moisture better than sandy soils, they usually contain less air than do sandy soils. A medium amount of air is preferred in the soil, and air circulation in the soil resulting from tile drainage is more helpful to the soil than the elimination of the surplus water. It is for this reason

that large tiles are often more satisfactory than small ones. They help to aërate the soil. Air in the soil aids bacteria in their work. Too much air in the soil is harmful, because it oxidizes or uses up the organic matter. A soil mulch helps to check the movement of the air into and out of the soil, and thus has as many advantages in controlling soil air as soil moisture. The amount of air in the soil depends upon the texture of the soil and the amount of water in it.

The chemical reactions in the soil depend upon the composition and texture of the soil, upon the amount of moisture and organic matter present, and upon proper temperature. All other things being the same, chemical reactions are greater in a fine clay soil than in a coarse sandy soil, because the clay soil exposes more surface to humic acids and to the soil water.

A close and careful study of the texture of the soil is important, for texture affects every vital process that occurs in the soil.

How the texture of the soil may be modified. — The texture of the soil may be modified by the addition of organic matter. This does not reduce the size of the original soil particles; but since the particles of the organic matter are much smaller, it reduces the average size in sandy soils. The addition of organic matter to sandy soils and the resulting change in soil texture increase the water holding capacity, lessen air circulation, and hasten chemical changes in the soil.

The texture of clay soils and loam soils is affected in the opposite direction. They are made looser by the addition of organic matter, and the passage of air and water is increased by the addition of organic matter. Clay soils that plow heavily may be made to plow much more easily if sufficient organic matter is added.

Soils named according to texture. — Soils are named mostly in accordance with their texture. The structure and color also are considered; but for our purpose here we shall consider texture alone as a basis for naming soils. The percentage of coarse sand, clay and silt determines what name shall be applied. If sand predominates, then it is a sandy soil; if clay, it is a clay soil; etc.

The study of the following table gives one a fair idea of the six leading types of soils.

PERCENTAGE COMPARISON OF SIX TYPES OF SOILS BASED UPON TEXTURE

	Clay Soil	Clay Loam	Silt Loam	Fine Sandy Loam	Sandy Loam	Coarse Sand
Clay . . .	50	35	20	15	15	5
Silt . . .	30	42	60	30	20	10
Very fine sand	12	15	10	25	15	10
Fine sand .	5	5	6	20	25	30
Medium sand	2	2	2	5	10	25
Coarse sand .	1	1	1	4	10	15
Fine gravel .	0	0	1	1	5	5
Total .	100	100	100	100	100	100

From this table it will be seen that a clay soil contains fifty per cent sand, thirty per cent silt, twelve per cent very fine sand, and eight per cent other soil separates. This means that a clay soil is made up almost wholly of very fine soil particles.

A coarse sandy soil according to the above table contains about eighty per cent of sands of various grades, five per cent gravel, ten per cent silt, and five per cent clay. This means that a sandy soil is made up of sand mostly.

Peaty soils have from twenty-five to seventy-five per cent or more organic matter. The other material is made up mostly of clay, silt, and occasionally sand. Peaty soils are very black (almost coal black) because of the large amount of decayed organic matter present.

A loam soil is composed of about equal parts of clay, silt, sand and a lot of organic matter such as we find in a peaty soil. From the above table it is seen that a fine sandy loam contains fifteen per cent clay, thirty per cent silt, twenty-five per cent very fine sand and twenty per cent fine sand. Such a soil has approximately the above composition with a lot of decaying or decayed organic matter in it, which gives it its black color.

Kind of crop depends on soil texture. — The kind of soil and its texture have a practical application; they determine partly the character of the crop that will thrive best. Sandy soils are adapted to early truck gardening. Radishes, lettuce, rhubarb, early cabbage, onions, melons of various kinds, pumpkins, squashes, and potatoes do well in a sandy soil. Peas and early bush beans may be grown in a sandy soil.

Clay soils are suited to the growing of grass. Blue-grass thrives best in a soil containing sixty to seventy-five per cent clay, fifteen to twenty per cent silt, a small amount of sand and about twenty-five per cent moisture.

The black loam soils of the Mississippi Valley are adapted to general grain farming and grazing. Corn, oats, wheat, late truck and fruits thrive upon this type of soil. The ideal corn land has about forty per cent of fine sand, thirty per cent clay, about twenty-five per cent silt and twenty per cent moisture. Wheat land may be slightly finer in texture.

Whitney gives the following number of soil particles per gram of soils as best suited to the production of different crops.

Early truck	1,955,000,000
Truck and small fruit	3,955,000,000
Wheat	10,228,000,000
Grass	15,000,000,000

No definite rules can be laid down regarding the relation of size of soil particles to crop adaptation because many other factors, like lay of land, rainfall, tillage, addition of manure and previous cropping affect the situation. It is expected that the above points will be taken as suggestive only.

Crop yields influenced by the texture of the soil. — It has been observed by all that plants wilt much more quickly upon clay soils than upon sandy soils. This is true because sandy soils will yield to plants their water supply to a greater extent than will clay soils. Water in sandy soils has a more rapid capillary motion. Plants may still grow without suffering in a sandy soil when the soil moisture is down to two or three per cent. But

when the moisture in clay soils gets down to fifteen per cent, plants may begin to wilt and suffer for lack of available moisture. The soil moisture moves so slowly in clay soils that an insufficient amount of moisture is supplied the plant. The yield of crops thus varies greatly because of the texture of the soil. The following yields of corn were secured under similar culture but with different soil texture.[1]

Massachusetts	10.3 bushels
Connecticut	12.5 bushels
New York	16.3 bushels
Indiana	38.2 bushels
Ohio	40.0 bushels
Michigan	44.7 bushels

To quote the bulletin: "These soils were unquestionably under different climate conditions but presumably under about the same conditions of cultivation, and from the description given of the several soils it would appear that the difference in yield is to be attributed mainly to the difference in the texture of the soils."

Rainfall is important, but that soils must hourly supply and bring to the plant sufficient soil water is more important. We are rapidly learning that if we are to secure good yields, the soil must constantly deliver water to the plant. The delivery of soil water to the plant is largely dependent upon the texture of the soil, therefore, texture is an important factor in influencing crop yields.

Soil surveys and soil maps. — The United States Bureau of Soils was organized in 1895, and since then has surveyed at least half of the counties of the United States. Over fifteen hundred counties have been surveyed. The classification of soils according to the Bureau of Soils is based mainly upon soil texture and structure, and color of the soil is also considered. If your county has been surveyed it will be interesting to secure a soil map. These maps may be had from the County Agricultural Agent or

[1] Farmer's Bulletin, No. 22.

the United States Department of Agriculture, Bureau of Soils. Soil survey maps will be of great assistance in the study of soils of your locality.

Summary. — Soil texture refers to the size of the soil particles. There are seven sizes of soil particles; namely, fine gravel, coarse sand, medium sand, fine sand, very fine sand, silt and clay. The surface area of a cubic foot of clay is much greater than the surface area of sand. Water percolates through sand much more rapidly than through clay. Sandy soils are warm soils because they permit the water to pass through them readily and because they are well aërated. Sandy soils are adapted to truck farming, and clay and sandy loams to grass and grain farming. The water holding capacity of clay is about two and one-half times as great as that of sand, but sandy soils give the water up more readily to plants than does clay. The texture of soils may be modified to some extent by the addition of organic matter. Crop yields are influenced to a considerable extent by the texture of the soil. The soil survey and map of your county should be carefully studied.

QUESTIONS

1. Define soil texture.
2. What are the relative sizes of the different soil particles?
3. What amounts of water will a coarse sand, clay and humus hold?
4. What percentage of different soil particles are found in a clay soil? Clay loam soil? Sandy loam soil?
5. Discuss six crops relative to the kind of soil they prefer for their growth.

PROBLEMS

1. Report upon the soil survey of your county, or some other county.
2. Suggest three laboratory exercises relating to soil texture.

REFERENCES

Whitson and Walster, Soils and Soil Fertility.
Vivian, First Principles of Soil Fertility.
King, The Soil.
Gehrs and James, One Hundred Exercises in Agriculture.

CHAPTER XXV

STRUCTURE OF SOILS

Puddling of soils. — If clay or loam soils are driven over, tilled, or tramped when slightly wet, they pack readily, and when they dry out they become hard. Heavy rains cause a hard crust to form upon the surface of many soils. The crust so formed is in poor physical condition. Walking over gardens when they are wet often does more harm to them than the removal of plant foods during one season. Driving in fields even with a broad-tired wagon is very injurious to the soil. Fields or pastures should never be grazed when the soil is wet.

What causes the soil to form a crust after a rain, or what causes it to become packed if tramped when wet? Just as snow packs readily when at the proper temperature, so some soils pack readily when they contain an abundance of moisture. The soil particles slip, one upon another, and in this slipping process the soil particles are compacted or stuck very closely together. Soils that in a loose condition are six inches deep will occupy a depth of less than four inches after they are thus compacted. The compacting of soil is called puddling.

If the student will take two samples of dry clay and wet one thoroughly and leave the other sample dry, and then work each batch of clay and set away for several days to dry, he will find that the one batch of clay has become very hard. What has really happened? One soil has become compacted, or puddled, and the soil particles slipped one upon the other so that they are forced very closely together. The other has maintained a good structure.

Meaning of soil structure. — The following figure shows how soil particles may rest one upon the other. As long as they remain in that position the soil is in good tilth.

In this picture each soil particle touches four other soil particles, and in reality each touches only six other soil particles. The soil particles are about as far apart as they can get and still be together. It is a soil that is loose, friable and in good tilth.

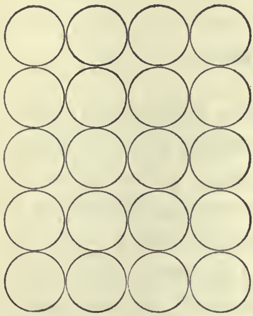


FIG. 147. — Soil particles in a loose condition and showing good structure.

But suppose we wet the soil represented in figure 147 and then step on it with a slight push. What will happen? The soil particles will assume the position as shown in figure 148.

Each particle now touches six other particles as shown in the picture below, and will in reality touch at least eight other particles. What has happened? The arrangement of the soil particles has been changed. The soil has been compacted and after it has dried will form a very hard soil, — one that will not respond to culture readily. Such a compacted soil will not permit free and ready air circulation and other processes due to chemical and bacterial action, which are absolutely necessary for thrifty plant growth.

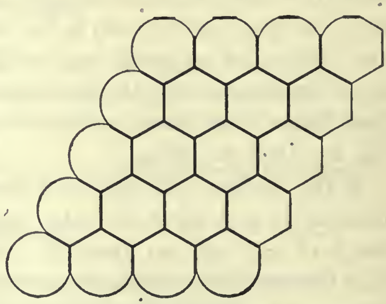


FIG. 148. — Puddled condition of the soil particles. Such a soil is in poor tilth. The structure has been broken down.

The best arrangement of soil particles is shown in figure 149.

This arrangement is a granular one and is conducive to carrying on the processes necessary to plant growth. Such a soil is said to be flocculated, or in good tilth. It possesses a structure that makes the soil friable, or workable, and actually sets free a maximum amount of plant foods. "Soil structure"

then refers to the arrangement or grouping of the soil particles. Bacteria thrive in a soil of good structure if some organic matter is supplied, and plant growth is in a large measure commensurate with

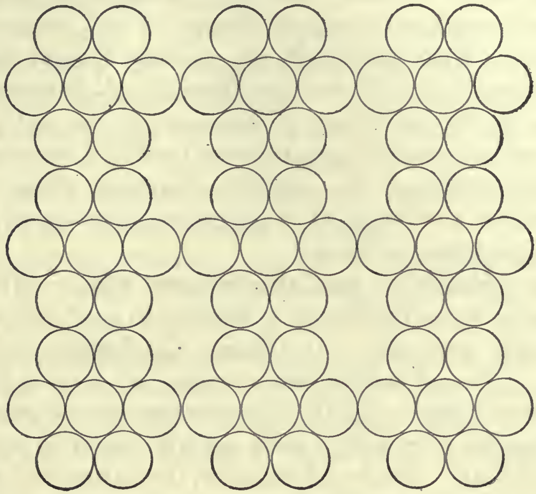


FIG. 149. — An ideal flocculated structure of the soil. The soil is in good tilth, and the processes of the soil are at their optimum for plant growth.

the activities of the soil bacteria. Chemical reactions are at their height in such a soil, if other conditions are favorable and plant growth is again, in large measure, proportional to the chemical reactions in the soil.

Causes of bad structure in the soil. — Poor structure in the soil is caused mainly by three things: (1) Improper tillage; (2) Lack of organic matter; and (3) Lack of drainage.

1. If soil is worked when wet, it becomes so hard and compact that it requires a season or two to get it back into proper tilth. And as long as the soil is in poor tilth it is hard to handle and does not yield good returns.

2. Many of the corn, wheat and oat producing fields in the United States are in poor tilth because of lack of organic matter. Because the soil has been constantly tilled and the crops removed,

many fields have been left void of organic matter. When the soil runs together after each rain and compacts so that it is hard, it is a sign of the absence of organic matter.

3. Some of our lowlands, especially the black gumbo soils, are not in good structural condition because of the presence of too much water. When these soils are properly drained they often make the very best soils, because drainage aids in aëration, and this helps in the structural arrangement of the soil particles. Uplands too are often in poor physical condition because of lack of sufficient drainage. To conclude, improper tillage, lack of organic matter and improper drainage are often causes for poor structural conditions of the soil.

Factors conducive to good structure and tilth. — While there may be other factors which are conducive to good soil structure, the principal ones are: (1) Tillage; (2) Addition of organic matter; (3) Use of winter cover crops; (4) Use of lime; (5) The freezes of winter; and (6) The growing roots of plants.

1. Tillage has ever been a most powerful factor in putting the soil in good tilth. The use of the plow, the harrow and the roller or drag is a potent factor in overcoming impotency of soil processes. Stirring the soil after a rain, and thereby breaking up the soil crust, conserves the moisture, admits the air into the soil and helps to make plant foods available.

2. Organic matter, whether added to the soil in the form of barnyard manure, green cover crops, or plants and stubble, has an important effect upon soil structure. Organic matter incorporated into the soil prevents puddling of the soil to a considerable extent.

3. Winter cover crops protect the soil from beating rains and shield it from the direct rays of the sun. The sun burns out organic matter, and hence affects soil structure. It is the belief of the author that cover crops will help greatly in maintaining good soil structure and in maintaining or improving soil fertility.

4. Liming the soil not only sweetens it but flocculates the soil particles. In other words it helps to make the soil granular.

Soil particles group themselves around other soil particles as shown in figure 149. A garden that packed with every rain was limed and manured. Its tilth was improved and its productiveness approximately doubled.

5. Winter freezes improve the physical condition of the soil as no other factor will. A soil that has been exposed to a cold winter has a "crumbly" structure. It crumbles and falls apart easily. Farmers often say after a severe winter that there will be a good corn crop. And if no beating rains come in the spring, the statement is loaded with some truth, for the freezing winter has left the soil in good physical condition.

6. Growing and decaying roots aid in improving the physical condition of the soil. Deep penetrating legume roots loosen the soil and upon decaying leave it looser and more porous. The decaying roots of grasses and other plants improve soil structure.

These six factors, tillage, addition of organic matter, use of winter cover crops, use of lime, freezes of winter and growing roots are important factors in influencing or improving soil structure.

Why plants grow well in a soil of good tilth. — No one would expect to grow a good garden or crop if he did not plow the soil and keep it in good physical condition. Why do plants thrive better if the soil is in good tilth? In the first place, plants do best in a loose soil because the roots can permeate easily, without physical effort, every small space of the soil. The roots reach out in great bunches like double hands put together, as shown in the figure, page 398, for plant food.

These little rootlets entwine about the soil particles and voraciously devour all the plant foods the soil will readily give up.

In the second place, soils that are compact will not admit sufficient air. When the plant is growing rapidly, the chemical processes and bacterial action of the soil must be continued correspondingly, for otherwise not a sufficient amount of plant food is liberated. The organic matter in the soil does not give up its chemical ingredients unless there is sufficient air present. And

since air cannot well penetrate a compact soil, it is evident that we cannot have good vigorous plant growth in such a soil. Hence, plants will thrive in a loose soil because it admits air.

A third reason why plants do better in a soil of good tilth is that the soil moisture is kept in a more satisfactory condition than in a compact puddled soil. A hard soil cracks open in dry weather and becomes water logged in wet weather. A soil of good tilth holds its moisture remarkably well even in extremely dry seasons, and permits the water to percolate through it in extremely wet conditions. This is another reason why plants do better in a soil of good tilth.

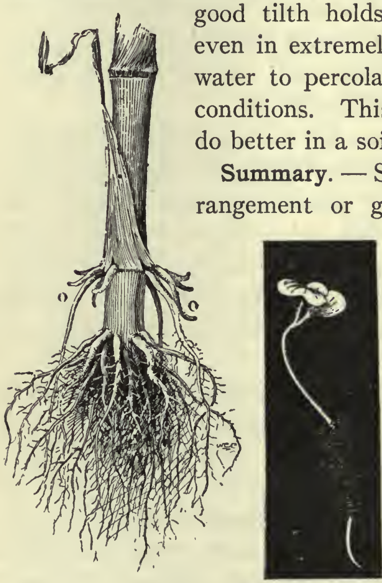


FIG. 150. — Note the abundance of roots and root hairs — soils in good tilth are in close contact with the roots and root hairs.

Summary. — Soil structure refers to the arrangement or grouping of the soil particles. When the structure of a soil is broken down, it is said to be in a puddled condition. When the soil is in such a condition plants will grow reluctantly because the processes essential to plant growth are at low ebb. On the other hand, when the soil is put in good structural condition by tillage, addition of organic matter, winter cover crops, lime, the winter freezes and the growing roots of plants, then it is in a condition favorable to the processes essential to plant growth. The factors in improving soil conditions should be carefully studied and practiced for they aid in permitting the air to circulate in the soil and thus induce the bacterial and chemical changes necessary to making available an abundance of plant foods.

The physical properties of the soil should be carefully guarded, protected and improved, for thrift in plant growth depends as

much upon the physical properties of the soil as upon its chemical properties.

QUESTIONS

1. What is the meaning of soil structure?
2. What are some things that cause puddling?
3. Why do plants usually grow well in a soil of good tilth?
4. How may the structure of the soil be improved?

PROBLEMS

1. Discuss the difference between the physical and chemical properties of the soil.

2. Discuss cover crops as a factor in improving the physical condition of the soil.

REFERENCES

Whitson and Walster, Soils and Soil Fertility.
Vivian, First Principles of Soil Fertility.
Burkett, Soils.

CHAPTER XXVI

PLANT FOODS

Physics and chemistry of the soil. — In the four chapters just preceding, the physical properties of the soil were discussed. The formation of the soil, soil forming agencies and soil texture and structure are physical aspects of the soil. The importance of the physical properties of the soil can hardly be overemphasized, for the chemical, bacterial and other processes of the soil depend very greatly upon its physical condition. Plants will grow poorly in a soil in which the structure is broken down. In the past we have not given sufficient attention to the physics of the soil, for it is one of the most essential factors in plant production.

We now turn to the *chemistry* of the soil, and the following chapters will deal largely with the chemical properties of the soil. Plant foods in the soil — how these may be lost and how they may be added — are topics for further treatment. The chemical composition of the soil, the sources of the plant foods, their function, form a study correlative to the study of the physical properties of the soil. The fertility of the soil is the chemistry and physics of the soil, and let us not forget that the perpetuity of the race is directly dependent upon the fertility of the soil.

Cycle of life or over and over again. — Plants take up plant foods from the soil, store them up temporarily, then die, decay and disintegrate, and add their substance to Mother Earth again. They gather plant foods from the soil and from the air — chemical elements and chemical compounds — build them with the aid of the energy-giving sun into foods in the plants. These foods in the plants are similar to the plant foods in the soil — containing the same chemical elements and compounds and possessing this

difference only, that the proportions are different. How could plants be much different in chemical composition from the soil from which they come? The plant life that is consumed by animals is returned for the most part to the soil. Eighty per cent of the plant foods eaten by animals are returned to the soil in the manure. The animal, upon death, returns the other twenty per cent. The old statement — " that nothing is ever gained or lost " — holds quite true of Mother Earth. From soil to plant and occasionally from plant to animal, but always back to soil, — this over and over again is the cycle of plant foods.

Foods required by plants. — Plants require those foods that they store up. Then the quickest way to see what their requirements are is to see what their chemical composition is. The chemical composition of 1000 pounds of corn plants, ready to be put into shock, is as follows:

Chemical Composition of the Corn Plant

Corn plant 1000 pounds	Water 793	Hydrogen 88.1		
		Oxygen 704.9		
	Dry matter 207	Organic matter 195	Protein 18	Nitrogen 2.9
			Fat 5	Carbon 90.5
			Fiber 50	Oxygen 88.9
			Carbohydrates 122	Hydrogen 12.7
		Ash 12	Chlorine 0 4	
			Potash 4 0	
			Phosphoric acid 1.2	
			Lime 1.6	
			Magnesia 1.4	
			Iron oxide 0.3	
			Sulphuric acid 0.3	
			Soda 0 4	
			Silica 2.4	

Other plants, with some variations, are like the corn plant. The corn plant is taken here as a representative plant in chemical composition. From the composition above given it may be seen that hydrogen, oxygen, carbon and nitrogen, with the exception of 12 pounds of ash, compose the entire 1000 pounds of corn plant. These four elements, in the form of water, protein, fat, fiber and

carbohydrates, constitute 98.8 per cent of the entire corn plant. All the ash elements in the corn plant except chlorine are in combination with the element oxygen. Other plants, although varying from corn in the amounts of different chemical compounds, are very much like the corn plant in composition.

What plant foods we find in the soil. — The *ash elements*, — phosphorus, calcium, iron, sulphur, magnesium, sodium, silicon, and chlorine, — all in combination with oxygen, are found in the soil. The last three are not essential to plant growth.

Just a few of the more important ash elements will be discussed. Silicon in combination with oxygen forms sand. Sodium and chlorine make common salt. Potassium combined with chlorine makes nitrate of potash, and with nitrogen and oxygen forms potassium nitrate. Iron is found in abundance in soils, where it is combined with oxygen. The reddish brown color of some soils is due to the iron rust in them. Magnesium plus sulphur makes magnesium sulphate or epsom salts. These are the essential mineral or ash elements in the soil. The three ash elements most frequently lacking in the soil are calcium or lime, phosphorus and potash. All the rest are usually present in sufficient quantities.

The elements, nitrogen, hydrogen, oxygen and carbon, constituting 98.8 per cent of the corn plant, come from the soil and the air. Hydrogen and oxygen combined make water, which constitutes from 75 to 90 per cent of green plants. Water comprises from 20 to 25 per cent of the weight of average loam soil under good field conditions. Its importance to plant growth will be discussed in the next chapter. Carbon in the form of carbon dioxide is taken into the leaves of plants, and in the green chlorophyll of the leaves it combines with hydrogen and oxygen. Nitrogen, making up four-fifths of the air, is used by the legumes directly, through the help of soil bacteria in the form of soil air. Nitrogen in decaying organic matter changes to nitrates which can be absorbed by any plant.

The foundation rock from which the soil was made plus the organic matter added to the soil is the source of many of the plant foods.

Function of the different plant foods. — Water is one of the chief foods of plants. Its functions are: (1) To actually help build up the plant; (2) To carry other plant foods in solution into the plant; (3) To equalize the temperature of the plant by transpiration. Carbon, hydrogen and oxygen form the *carbohydrates*, which comprise the starches and the sugars. *Fats* are likewise composed of these three elements. Carbon, hydrogen, oxygen and nitrogen make up the *protein* substances in the plant body. Luxuriant green plant growth is an indication of an abundance of available nitrogen. Often pear and apple trees grow so luxuriantly that they refuse to bear. One reason for this in many cases is an oversupply of nitrogen and a lack of other elements. Nitrogen must be supplied if protein substances are to be grown. The nitrogenous ingredient in plant growth is the most valuable and is often scarce in the soil. Nitrogenous fertilizers are high in cost. The composition of the corn plant indicates in a quantitative way the function of the elements that are to make up the organic part of the corn plant.

The ash elements form a small part of the plant. The ash ingredients in a few feeding stuffs are shown in the following table:

ASH INGREDIENTS PER 1000 POUNDS

	Total Ash in 1000 Lb.	Pounds of Each								
		Potash	Soda	Lime	Magnesia	Iron Oxide	Sulphuric Acid	Phosphoric Acid	Silica	Chlorine
Wheat . .	26.15	5.3	1.6	0.6	2.2	0.23	5.4	8.6	0.4	0.82
Wheat bran	64.54	16.2	2.4	0.9	7.3	0.34	6.7	29.5	0.3	0.90
Alfalfa hay .	81.00	22.3	5.6	19.5	5.9	1.68	7.8	5.4	8.1	4.74
Skim milk .	16.4	1.7	0.6	1.8	0.2	0.0	0.8	2.2	0.0	0.91

Potash helps to build stems, especially giving stiffness; lime aids in forming leaves; phosphorus assists in forming the kernels of plants and hastens maturity. The other ash elements also

help plant growth. The complete function of the ash elements is not now known.

Amount of plant foods in soils. — The following table gives a fair notion as to the composition of a few soils, giving the nitrogen, phosphorus and potassium content per acre.

AMOUNT OF PLANT FOOD PER ACRE IN THE SURFACE FOOT

	NITROGEN	PHOSPHORUS	POTASSIUM
Peat . . .	11,865	550	1,697
Sand . . .	1,675	620	39,750
Clay . . .	3,250	5,600	12,600

A close study of the table will reveal what fertilizers, if any, are to be applied to different kinds of soils. A peat soil is rich in nitrogen, and poverty-stricken in phosphorus and potassium. It is evident that it does not need a nitrogenous fertilizer. A sandy soil may need nitrogen and phosphorus.

Amount of plant foods removed by plants. — Corn, wheat and oats remove the following amounts of food elements.[1]

AMOUNT OF PLANT FOOD REMOVED BY PLANTS

	NITROGEN	PHOSPHORUS	POTASH
Corn, 30 bushels	43 pounds	18 pounds	36 pounds
Wheat, 30 bushels	48 pounds	21 pounds	28 pounds
Oats, 45 bushels	55 pounds	19 pounds	46 pounds

How many years would it require corn to remove the nitrogen, phosphorus and potash from a clay field, which has the composition indicated in the preceding table, corn yielding thirty bushels per acre yearly? It would require 76 years to remove the nitrogen; 300 years to remove the phosphorus; and 350 years to remove the potassium. This clearly indicates that the plant

[1] Warington.

foods of the soil cannot be quickly removed. And we should bear in mind if the same land were tilled in the same crop year after year, it would soon refuse to release as much plant food as it did the preceding year or decade. This is a fortunate thing, for it protects the soil from the unscrupulous soil robber.

Three forms of plant foods in the soil. — Plant foods exist in the soil in three forms, namely:

1. Plant foods that are immediately available.
2. Those that are not immediately available.
3. Those that are firmly secured in the soil.

1. The plant foods that are immediately available to plants constitute a small part of the total plant food in the soil. The plant foods are held in solution by the soil water, and if plants are present they are used; if not, they may leach away. Good soil texture and structure and plenty of organic matter prevent to a large extent the leaching away of plant foods. Cover crops help hold available plant foods, — for in this case the available plant foods get into the round of over and over again, — and the plants hold secure for a short time the foods that the soil yields them.

No one could guess or even determine what quantity of plant foods are available and made available in one season. This, in fact, depends upon several conditions (discussed in the next paragraph) but that probably less than one-hundredth part is available in one season is a safe conservative estimate. This is a fortunate thing indeed, for if all the plant foods became available in one season, exhaustion of the soil would soon occur.

2. The plant foods that are not immediately available to plants, found in the surface soil, make up another fractional part of the total plant foods in the soil. Let us think of this form of plant food in this way — there are some plant foods available; others are becoming available in 30, 60, 90, 180 and 360 days. The rock particles in the soil in the presence of humus yield up slowly their plant foods. Year in and year out chemical and bacterial

processes are going on in the soil, ever changing and drawing upon Mother Earth, trying to get plant foods. The plant foods that are not immediately available do not help or contribute plant foods to the growing plant. These plant foods will yield themselves to service later.

3. Those plant foods that are firmly secured in the soil constitute probably ninety-nine per cent of all the plant foods in the soil. The bowlders and rocks hidden beneath the surface of the soil — in some places near the surface, in others farther away — hold within themselves plant foods that will feed plants hundreds and thousands of years from now. The surface soil was made from these original rocks and it took ages to do it. These parent rocks deep down in the soil are the permanent storehouses and securities of plant foods forever. But even these permanent storehouses will finally, as the result of heat and cold, plants and animals, sunshine and rain, yield themselves to plant growth, if they are needed.

Although chemical analysis is very valuable in determining the total amount of plant foods in the soil, it does not show the amount of plant foods available for plant growth. Hence chemical analysis is rather of indirect than of direct value.

How to make plant foods available. — Some of the factors that help to make plant foods available or set them free are:

1. Tillage, keeping the soil in good tilth, is the greatest factor in setting foods free, so plants can use them. Tillage, too, helps in giving the roots of plants more surface area upon which to feed, thus enabling them to utilize the available plant food. The structure of the soil must be in proper condition if a maximum amount of plant food is to become available.

2. The addition of organic matter does more than to add a great deal of plant food. It aids in drawing plant foods from the rock particles.

3. Proper drainage carries out the excess water. Plant foods are not made available rapidly where there is an excess of water, for the water keeps out the air, and air must be present if chemical

and bacterial changes are to go on to set plant foods free. From twenty to twenty-five per cent moisture is the optimum amount for plant growth.

Balancing the ration for plants. — Plants, like animals, must have a balanced ration if they are to yield well. The following figure shows to some extent the significance of an unbalanced ration in plant growth.

The picture shows the importance of providing nitrogen if clover is to thrive. It is just as true that all other essential elements must be provided if the plant is to thrive.

FIG. 151. — In pot No. 1, clover without nitrogen being present in the soil. In pot No. 2, clover is growing. Nitrogen was added to the soil.

The chemical composition of plants given in this chapter indicates the needs of plants, but all the ingredients needed must be supplied in much greater abundance than the composition of the plants indicates. That this is true is shown by the composition of a few soils given in a previous paragraph.

Balancing plant foods is an important matter. One element cannot take the place of another element. To quote "Productive Agriculture": "If there is sufficient nitrogen in a soil to produce forty-five bushels of wheat to an acre, potassium to produce fifty bushels, and phosphorus to produce twenty bushels per acre, the maximum yield cannot exceed twenty bushels per acre, because the scarcity of phosphorus in the soil prohibits the greater yield. It is an unbalanced ration in the supply of plant foods. Phosphorus is the limiting factor. 'No chain is stronger than its weakest link.' The weakest link in the above chain is phosphorus."

The balancing of plant foods will be further discussed in the chapters, Improvement of the Soils, and Fertilizers.

Summary. — The plant foods in the soil are all important in the perpetuation of a successful agriculture and of a successful

race. Plants are the medium through which plant foods are taken from the soil and returned to it. Plants require hydrogen, oxygen, nitrogen, carbon, potash, calcium, phosphorus, magnesium, iron and sulphur in their growth. The three non-essential plant foods, often found in plants, however, are sodium, silicon, and chlorine. All of these elements are found in the soil. The essential ones do their part in building up plant tissue and each

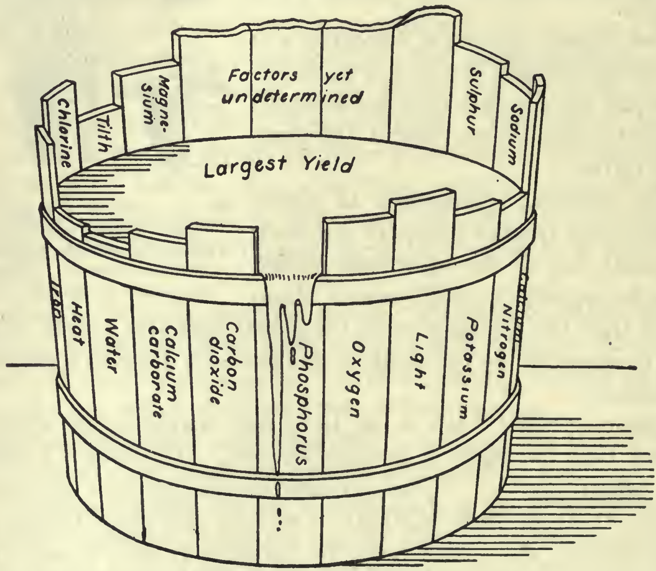


FIG. 152. — Just as the height of the lowest stave determines the amount of water the barrel can hold, so the yield of a crop on a field is determined by that element or condition which is least satisfactory.

has a definite rôle to play in this master building process of the plant. One element cannot take the place of another element in plant growth. The amount of plant foods in the soil, in an available, not immediately available and a tightly secured form is fortunately fairly large. That the earth yields up its storehouse of plant food slowly is a fortunate thing. Man may by tillage, addition of organic matter and drainage help make plant foods

available. Plants must be supplied a well-balanced ration if they are to produce at their optimum.

QUESTIONS

1. What is the meaning of the expression "over and over again," as applied to plant foods?
2. What plant foods are found in the soil?
3. Compare the chemical composition of the corn plant with the plant foods found in the soil.
4. What functions do the different elements have in plant growth?
5. Compare the lime and phosphorus content of bran and alfalfa.
6. Discuss the amount of plant foods in the soil.
7. Plant foods are found in what form?
8. What are the things that will aid in making plant foods available?
9. What elements are most likely to be deficient in the soil?
10. What is a balanced ration for plant growth?

PROBLEMS

1. Discuss the importance of the fact that most plants foods are securely locked up in the soil.

REFERENCES

Whitson and Walster, Soils and Soil Fertility.
Vivian, First Principles of Soil Fertility.
Burkett, Soils.

CHAPTER XXVII

SOIL WATER

Importance of water in crop production. — Water is more often the limiting factor in plant growth than any other single factor and for that reason should receive special emphasis. From sixty to ninety-five per cent of the green weight of the staple crops is water. And much more is needed in proportion to produce the dry matter which is found in the dry plant, for from 200 to 700 pounds of water transpire from crops for every pound of dry matter produced. The following table shows the amount of water transpired by different crops under different conditions per each pound of dry matter produced.

AMOUNT OF WATER TRANSPIRED PER EACH POUND OF DRY MATTER OF PLANTS PRODUCED

	LAWS & GILBERT, ENGLAND	HELLRIEGEL, GERMANY	WOLLNY, GERMANY	KING, WISCONSIN
Corn			233	272
Wheat	255	359		
Oats		402	665	557
Potatoes				423
Red Clover . . .	249	330		453

These figures vary a great deal and it is right that they should, for arid, warm, clay soils and windy conditions require more moisture than do the converse conditions. These figures all clearly indicate the vast amount of water plants need for their best growth. Plants need water for various reasons:

1. It makes up a large part of the composition of the plant and is an actual plant food.

2. It serves as a carrier of plant food. Plant foods are taken into the plant through water solutions. These plant foods are carried in such small quantities, especially the mineral ingredients, that it is necessary for enormous quantities of water to pass through plants in order that they may be properly nourished.

3. Water helps to maintain the proper temperature of plants. Water, in the transpiration process, cools the leaves to a considerable extent. Young shoots of plants would be burned up were it not for the cooling effect of the water that passes through them and transpires from the leaves.

Water is so important that Vivian, in *First Principles of Soil Fertility*, says, "There is no doubt, however, that the proper condition of moisture is the most important single factor in determining the fertility of the land, and that more soils fail to produce good crops for lack of it than for any other cause." Water in proper amounts and coming at the right seasons practically controls the yields. Twenty inches of rainfall when properly distributed is sufficient to produce the best corn yields; but when improperly distributed may result in an absolute failure of the crop. Sometimes an additional rain or two would double the crop yield. Hunt and Burkett, in *Soils and Crops*, say: "A piece of land was once planted in corn. The yield was 30 bushels per acre. The next year it was planted with the same kind of corn and otherwise treated as in the previous year. The yield was 90 bushels. During the first season, the rainfall for the five growing months was thirteen inches; the second season it was twenty-two inches for a like period. The extra nine inches of rainfall was the principal factor in producing the additional 60 bushels of corn."

Amount of water in the soil. — There are several ways of finding the per cent of moisture in the soil. United States Bulletin No. 9 gives a simple method: "The loss in weight upon drying soil at a temperature of 110° C. is the amount of moisture." That is, if one hundred grams of soil weighed eighty grains after drying, the per cent of moisture would be $\frac{20}{80}$ or 25 per cent.

The amount of water a soil holds depends upon the texture and structure of the soil, and the amount of organic matter it contains. The volume and per cent of water held by different soils is shown in the following table.[1]

WATER HOLDING CAPACITY OF SAND, CLAY AND MUCK

KIND OF SOIL	POUNDS OF SOIL PER CUBIC FOOT	POUNDS OF WATER PER CUBIC FOOT	PER CENT OF WATER IN SOIL AT SATURATION
Coarse sand	81	32.0	39.5
Clay	68	37.0	54.5
Muck soil	15	50.0	333.0

This table shows that a muck soil (the same is true of a peat soil) will hold much more water than a clay soil, and that a clay soil has greater water capacity than sand. Lyon and Fippin say, "The pore space may range from thirty-five per cent in a clean sand to sixty or seventy per cent in a well-granulated clay, and to eighty or ninety per cent in a muck soil." However, it should be noted that a sandy soil will give up its water content more quickly than a clay or muck soil. Crops will begin to wilt in a coarse sand soil when the moisture gets below 3 to 4 per cent; in a clay soil when the moisture gets below 17 per cent; and in a muck soil when soil moisture gets below 80 per cent. The average soil, containing 15 to 30 per cent water, provides, as far as soil water is concerned, optimum conditions for plant growth.

Burkett gives the following percentages of moisture for different soils and crops to produce best growth.

Early truck and potatoes . . .	15% water
Late truck and fruit	20% water
Corn	20% water
General grain	20% water
Wheat	15% to 20% water
Grass	20% to 25% water

[1] Lyon, Fippin and Buckman, *Soils*.

Three forms of water in the soil. — Water exists in the soil in three forms; as:

1. Gravitational water.
2. Capillary or film water.
3. Hygroscopic water.

Gravitational water is that water which moves in the soil by force of gravity. Under such a condition all the pore spaces are saturated with water, and the water is gradually sinking under the influence of its own weight. It was shown in the above paragraph how much water soils would hold under a saturated condition. Few plants can use gravitational water to advantage. When the soil is saturated with water the air is pressed out of the soil, and the processes essential to plant growth are greatly curtailed. It is for this reason that plants get yellow.

Capillary or film water is the water held on the soil particles by capillarity. If the finger is inserted into water and then removed, it will have a film of water about it. The capillary water is held similarly by the particles of the soil. The amount of capillary water a soil will hold depends upon its texture, structure and organic content. Clay soils will hold much more capillary water than sandy soils, and organic matter will hold more still. Buckingham found that fine sand, sandy loam, clay and peat hold 10, 15, 20 and 190 per cent capillary moisture respectively, which may be represented graphically thus:

Capillary Water Holding Power with 100 Pounds of Soil

Fine sand	10 pounds
Sandy loam	15 pounds
Clay	20 pounds
Peat	190 pounds

King found that corn was able to reduce the water in a sandy soil having a maximum capillary water capacity of eighteen per

cent down to 4.17 per cent; but in a clay soil having a water capacity of twenty-six per cent, corn was able to use the water down to only 11.79 per cent. The sandy soil had yielded 18.83 pounds of its moisture per cubic foot, whereas the clay had yielded 12.5 pounds. The point is this, that a soil having a small capillary water capacity like a sandy soil will yield its water to plants more readily and completely than the clay soils which have a greater water holding capacity.

The movement of capillary water may be in any direction. It may be upward; for plowed soils that appear dry during the daytime are black the following morning because moisture has come to the top of the soil.

Hygroscopic water is the water that condenses about the driest dust particles. The amount of hygroscopic water in dry road dust may range from one to four per cent. Sandy soils do not hold as much hygroscopic water as do clays or black loams. Hygroscopic water is unavailable to plants, therefore does not need further discussion.

How to increase the water holding capacity of soils. — Cultivation and putting the soil in the best of physical condition is an important factor in increasing its water holding capacity. Time of plowing is a powerful factor in increasing the water supply of a soil. At the Kansas Station[1] the time of plowing had the following effect upon soil moisture.

EARLY PLOWING HELPS IN CATCHING AND HOLDING WATER

	Gain in Moisture, June 1st to September 21st			Loss in Moisture from April 1st to May 31st		
	Moisture Content June 1	Moisture Content Sept. 21	Gain	Moisture Content April 1	Moisture Content May 31	Loss
Late fall plowed	14.9%	18.3%	3.4%	16.9%	15.5%	1.4%
Early fall plowed	13.7%	19.6%	5.9%	17.0%	14.6%	2.4%
Fallowed . . .	14.5%	21.5%	7.0%	20.4%	16.3%	4.1%

[1] Bulletin No. 206.

The table shows that fallowed ground gained more moisture from June 1st to September 21st; and also gave up more moisture from April 1st to May 31st; and still contained more moisture than did the late fall plowed soil. Fall plowed soil will catch and hold more moisture than spring plowed soil.

Since organic matter has about seven times the water holding capacity that clay has, it is quite evident that organic matter added to clay soils will help to increase the water holding capacity. Whitson and Walster state in *Soil and Soil Fertility*, "A piece of very sandy land was found in summer to have sixteen thousand pounds more water per acre where manure had been applied than where it was not." Manure will improve the texture and structure of the soil so that the rainfall will be taken into such a soil much more readily than where manure is not applied.

Sandy soils are also improved in their water holding capacity by compacting them. For this reason rolling or dragging has a good effect upon sandy soils.

Plants which shade the earth help the soil to hold its water content. When the soil is well protected from the sun and wind its moisture is pretty well guarded. Bare spots in the pasture or lawn permit the escape of soil moisture. As far as possible no soil water should be permitted to escape from the soil, agriculturally speaking, save through the leaves of useful plants.

Regulating the moisture supply in the soil. — This topic comprises three other topics: Drainage of Soils, Irrigation of Soils and Mulching Soils, — each one sufficient for a chapter. For the lack of space, only a brief discussion of each can be attempted here.

Drainage. — There are nearly 80,000,000 acres of swamp lands in the United States which may be reclaimed by drainage. These lands would make one million 80-acre farms, and provide homes for at least ten million people. These lands will be drained gradually as they are needed. Many clay uplands, as well as swamp lands, need draining.

What benefits may be expected from drainage of swampy, undrained soils? Larger crop yields may be expected, as the following picture indicates:

Fig. 153. — The left part of the figure shows a light yield of oats because of late sowing, due to a lack of drainage. The picture to the right represents the yield from a similar area of drained soil. It was sown early.

Why an increase in yield from drained soils?

1. Drainage takes out the surplus water. This permits the soil to become warm, and thereby lengthens the growing season anywhere from ten to forty days.

2. Drained fields suffer less from drought because the roots of plants penetrate the soil more deeply. This insures the plants more feeding surface and as a result more moisture.

3. Drainage opens up the soil, and permits the air to get in. This helps in making more plant foods available, for the oxidizing action of the air aids the chemical and bacterial processes in the soil.

4. Drained fields can be tilled and handled much more easily than undrained fields. This is a powerful factor in making plant foods available and in securing maximum crop yields.

5. Drainage prevents washing, and hence conserves the fertility of the soil.

6. Drainage makes waste lands available for agriculture, thus helping to swell crop production.

Tile drainage is probably cheaper than open ditch drainage for it lasts decades. All the soil can be cultivated and more cheaply; the crop grows best just over the place where the tile drain is located. In fact, tile drainage is superior in every respect to ditch drainage, except when a large open ditch is needed to carry away large amounts of water.

Tiles may be laid much deeper in a sandy soil than in a clay soil. The average depth of laying tiles is two to four feet. The fall depends upon the size of the tile. Four-inch tile must have a fall of at least two inches per hundred feet, but tiles having a larger diameter may have only one inch fall per hundred feet. Tiles less than four inches in diameter are not recommended, for they clog too easily and do not admit enough air to pass through them and into the soil. Air drainage is almost as important as water drainage in tiling land. It is for this reason that larger tiles should be used. The outlet of tiles should be well protected with wire netting to keep rabbits and rats out.

The two systems of arranging tiles are shown in the following figure.

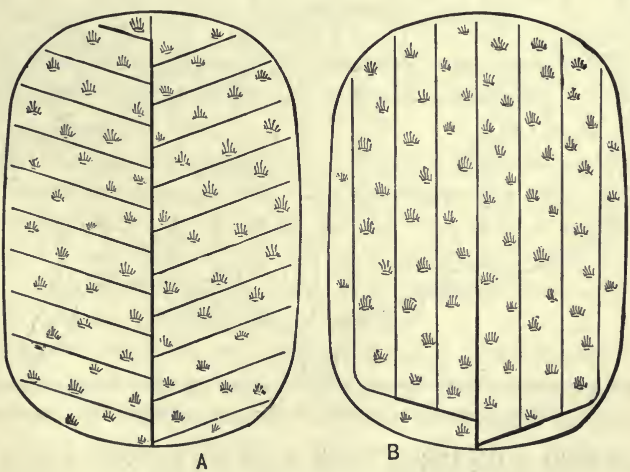


FIG. 154. — The two ways of laying tile.

An accurate map should be kept, showing location of the mains and laterals used in the drainage system for convenience in repair work.

The drainage of large areas is distinctly a government and state problem, for it requires the coöperative effort of local, state and Federal governments. Professor Shaler estimates that there are about 3,000,000 acres of land that may be reclaimed along the Atlantic seaboard of the United States. These lands when reclaimed by proper drainage are the most fertile and valuable lands we have. When drained they become productive and healthful, two requisites for productive agriculture. Drainage, then, is one of the large ways of regulating the moisture in the soil.

Irrigation. — The following map shows the average annual rainfall in the different parts of the United States.

FIG. 155. — The average annual rainfall in different sections of the United States.

Two-fifths of the United States is too dry to produce crops well, without irrigation. The total land now irrigated is upwards of

ten million acres. This, Warren tells us, is a little over one-thousandth of the arid area.

Hopkins tells us that a rainfall of from fifteen to twenty inches is sufficient for very fair crops if it comes at the rate of three inches a month from April to September. Irrigation is practiced where the rainfall is less than fifteen inches per year. If all the rain that falls in the arid regions could be used for irrigation, only about ten per cent of the arid land could be irrigated. Director Newell estimates that lands that could still be brought under irrigation are about equal in size to the state of Illinois, and would support about ten million people.

The water used in irrigation comes from streams, lakes, ponds and storage reservoirs. The water is carried by either pipes or trenches, and when it reaches the soil that is to be irrigated it is carried to its final destination by small ditches. There are four methods of applying the water; namely:

1. Flooding.
2. Furrow distribution.
3. Overhead sprays.
4. Subirrigation.

Each method of irrigation has its advantages and its disadvantages with different crops and different conditions. These will not be discussed here.

Dry farming is practiced in the Western States, where the rainfall in many places is less than twenty inches annually. Dry farming implies: (1) That all the rain that falls is absorbed by the soil; (2) That all the water is conserved; and (3) That plants like wheat, alfalfa, kafir, milo maize, feterita and others adapted to dry farming must be grown.

Often two years are required to get a crop in the Western States. The first year the ground is plowed, worked down and then a "soil mulch" maintained in order to catch, hold and conserve the water of rain and snow. The second year it is planted and such plants are used as are adapted to the semiarid condition,

plants that will grow in early summer and mature with a minimum of late rains. The principles underlying dry farming might well be observed in the entire country, for it is one of the best ways of conserving, regulating, and utilizing soil moisture, — essential factors in maximum crop production.

The soil mulch is an important factor in regulating soil moisture and crop production. — Much soil water is lost by evaporation.

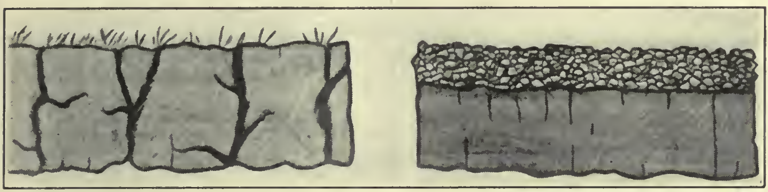
FIG. 156. — Cracks in the soil permit an excess of soil evaporation. They expose additional surface to the sun and wind.

A soil that is hard, packed, or cracked loses soil water rapidly, for the sun, wind and air take it up as fast as the water is exposed. The above figure shows a condition which permits the escape of the maximum amount of soil water.

Hard soils begin to crack upon the approach of dry weather. Nothing could happen that will more quickly reduce the plants, for the plant is rapidly being robbed of the moisture that rightfully belongs to it. When the moisture is once evaporated, it can never be regained. The question that confronts every soil husbandman is, How may I conserve the moisture that is in the soil of my farm?

The answer is the *soil mulch*. The soil mulch is a blanket of soil two to three inches deep made by cultivation. The mulch is not in close granular contact with the soil beneath, although the mulch should be granular. It breaks the capillary movement of the soil water. Cultivating the soil represented in the above figure would break the direct contact of capillary water and the direct forces causing evaporation.

The following figure shows the difference between a compact soil, conducive to evaporation, and a mulched soil which prevents the escape of soil water.



Courtesy Soil Improvement Committee.

FIG. 157.

Moisture escapes through cracks; the sun and wind are rapidly taking away the soil moisture.

A soil mulch prevents cracking and helps to hold the soil moisture. The soil mulch also breaks to a large extent the capillary rise of water in the soil.

Every soil husbandman of garden, orchard, or field knows the value of a soil, straw, sawdust, or leaf mulch. He also knows that stirring the soil during the hottest weather by plowing the corn conserves the moisture and increases the yield. To indicate the water saved by the soil mulch, the following figures are submitted (page 422).[1]

The authors state, " If the wilting point was six per cent, then the mulched soil contains more than twice as much available moisture as the unmulched." The table is worthy of the most careful consideration in the management of the soil.

A soil mulch from two to three inches deep has been found most effective. Stirring the soil after each rain in order to break up the crust formed by the rain is a good practice in conserving soil

[1] Lyon, Fippin and Buckman, *Soils, their Properties and Management.*

moisture. A fairly coarse granular soil mulch is most effective. A fine dust is undesirable, because the soil particles remain too close together in a finely pulverized soil mulch. The term "dust mulch" should disappear, and the word "soil mulch" be used instead.

MOISTURE CONTENT OF MULCHED AND UNMULCHED EASTERN MONTANA SOILS

Average of Three Years, October 6

	MULCHED	UNMULCHED
First foot	16.8%	10.8%
Second foot	16.4%	9.4%
Third foot	13.2%	9.5%
Fourth foot	10.1%	8.9%
Fifth foot	9.6%	8.5%
Averages	13.2%	9.4%

Level cultivation is also an important factor in saving soil moisture. Ridging corn and potatoes, known as laying by, is an abandoned practice, because ridging the soil exposes more soil to the sun and air, and therefore causes an excess evaporation.

Summary. — Soil water is important because it is the most frequent limiting factor of plant growth. Plants require from 200 to 700 units of water for transpiration for each unit of dry matter produced. The function of water is to build plant tissue, carry plant foods, and maintain the proper temperature of the plant. The average soil under good field conditions contains from fifteen to twenty-five or thirty per cent of moisture. The three forms of soil water are gravitational, capillary and hygroscopic. Capillary water can be used by field plants. Tillage, addition of organic matter and the shade of plants help to conserve the moisture of the soils.

Soil moisture may be regulated by proper drainage, irrigation, mulching and level cultivation. It behooves all of us to study most carefully the water of the soil, for upon it more than upon any-

thing else depends the productivity of the soil. If we want a big crop yield, we must carefully husband the water in the soil.

QUESTIONS

1. What is the importance of soil water?
2. How much water is transpired from plants to produce one unit of dry matter?
3. What is the function of water in plant growth?
4. What amount of water in soils is conducive to plant growth?
5. What are the forms of soil water?
6. Compare soils of different texture in their water holding capacity.
7. How may soil water be regulated?
8. What may be done to catch and hold the rainfall?
9. What means are at the disposal of the gardener or farmer to conserve soil water?
10. Does a small rain do more harm than good in a dry season, and why? What would you suggest regarding the conservation of the water deposited by the small rain?

PROBLEMS

1. Report upon the Principles of Dry Farming.
2. Report upon the specific amounts of soil water transpired by ten plants. Discuss the relation of the point to the adaptability of different plants to soils having different moisture conditions.

REFERENCES

Whitson and Walster, Soil and Soil Fertility.
Vivian, First Principles of Soil Fertility.
Burkett, Soil.
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CHAPTER XXVIII

FACTORS DECREASING SOIL FERTILITY

American Crop Yields. — "The fact that the United States stands seventeenth in acreage yields is evidence that something is wrong. Using the index figure one hundred to indicate the average yield per acre, Uncle Sam's batting average was only 108. Contrast it with the following: Hungary, 113; Austria, 120; France, 123; Norway, 128; Sweden, Chile, and Canada, each 136; Japan, 137; Egypt, 161; New Zealand, 167; Denmark, 168; Germany, 169; United Kingdom, 177; Switzerland, 202; Netherlands, 209; and Belgium, highest with 221."[1]

In the production of oats (1902–1911) the yields per acre of different nations stand as follows:

Germany	57.4 bushels
United Kingdom	44.7 bushels
France	30.0 bushels
Austria Hungary	31.0 bushels
United States	29.4 bushels

Even if the above figures are true, we should remember that in the United States, one man will sow, raise and harvest thirty or forty acres of oats; while in Europe one man will produce only one to three acres of oats. This means that one man in the United States produces many more bushels of oats than one man does in Europe. *And what we want is man yield, rather than large acreage production.* A large man yield can be secured only where large farms, large horses and large machinery are used.

The acreage yields in the United States for 1907–1916 of corn, wheat and oats were 26.0, 14.7, and 29.9 bushels respectively.

[1] United States Yearbook of Agriculture and Monthly Crop Reporter for July, 1918.

And the crop yields are not decreasing, but increasing, as shown by the following cut based upon Crop Reporter, January, 1911.

Figure 158 shows the conditions as they are relative to the ten leading crops of the United States. It may be noticed that in the last fifteen years the yields have been on the increase, and that the low yields prevailed from 1880 to about 1895.

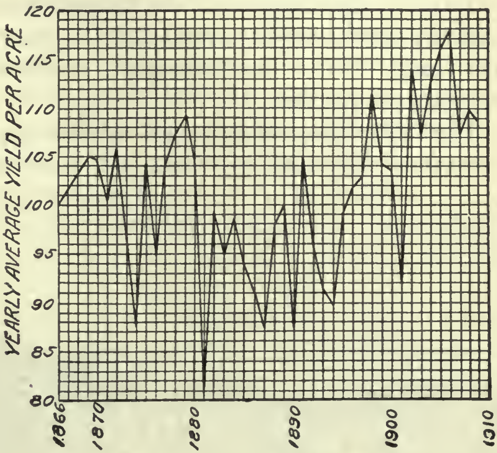

FIG. 158. — Yearly average yield of the ten leading crops combined. These crops represent almost 95 per cent of the area of all crops. 100 represents the average for 43 years. Note the increased yields in the last decade.

The increase in yields the last fifteen years has not been due so much to an increase in the fertility of the soil, but rather to better methods of farming, use of improved varieties, better culture, rotation of crops, etc. As a matter of fact, the fertility of the soil is difficult to maintain.

Factors decreasing soil fertility. — Some of the factors causing a decrease of soil fertility will now be discussed, such as: (1) Soil erosion; (2) Constant cropping; (3) Loss of humus; (4) Breaking down of physical condition of the soil; (5) Loss of nitrogen; (6) Alkali soils due to water-soluble salts; and (7) Lack of soil conditions that foster bacterial growth.

1. *Soil erosion.* — Soil erosion causes the greatest loss of soil fertility. No other single factor lays such a heavy tax upon the fertility of our soils. The United States Yearbook of Agriculture of 1916 estimates the annual loss due to erosion at approximately $100,000,000. This enormous tax, laid upon the 899,000,000 acres valued at $28,000,000,000, is a constant drain upon our

resources, which never brings any returns, and leaves the soil permanently depleted. Soil erosion has led to the abandonment of farms in various parts of the United States. "It is estimated that the United States is worn down at the rate of one inch every 760 years. This is rapid enough to construct the Panama Canal in seventy-three days." [1]

The United States Yearbook of Agriculture, 1916, says: "Already some four million acres of farm land have been ruined by erosion

Courtesy U. S. Dept. of Agriculture.

FIG. 159. — Fertile land ruined by erosion. If the soil-washing is not checked there is danger that the buildings in the background will eventually be undermined.

and nearly twice as much more has been seriously damaged. In other words erosion has rendered completely non-productive an area capable of forming nearly one hundred thousand farms, and of sustaining a population approximately equal to that of Arizona and New Mexico combined. Every year there is an

[1] Lyon, Fippin and Buckman.

unnecessary wash from erosion of more than four hundred million tons of soil material. Even a nation as rich in its resources as the United States cannot afford a loss of this magnitude."

A story is told of a man who built his house upon the sand and the floods came and washed it away. Some of our farming may be likened unto the picture, for the washing away of the soil is certainly undermining our soil fertility and gradually strangling one of our largest resources. The opposite figure will illustrate the necessity of protecting our homes or forever losing them.

Soil erosion is due to the following conditions: (1) Slope; (2) Lack of vegetation; (3) Character of rainfall; and (4) Physical condition of the soil.

Slopes with a fall of more than fifteen degrees should not be cleared. However, some soils on slopes of less than fifteen degrees will wash easily. And even almost level fields may erode a great deal.

A lack of vegetation often permits erosion. Gullies form where the stock have worn away the vegetation and made a path. The fine root systems of grass are very effective in holding the soil together. Slowly falling rains seldom wash the soil, but a heavy rain is often rightly spoken of as a gully washer.

Soils with fine texture and poor structure erode readily. Coarse sandy soils containing a lot of organic matter will not erode as readily. But the soil that has been tilled continuously and has lost most of the organic matter must be managed carefully, or there will be none to manage in a season or two.

There are several means available to prevent erosion.

1. Keep gradually sloping land in grass, and protect open ditches with sod and hillsides with forests, as indicated in the following picture.

2. Banks of streams should also be protected from the flowing water by a fringe of trees.

3. Open ditches having gentle slopes along the hillsides will prevent erosion. Plowing and cultivating should be along the side of the slope rather than up and down the slope.

4. Increasing the water holding capacity by putting the soil in the best physical condition and by the addition of manure will assist greatly in preventing erosion. A soil in good physical condition does not wash easily.

5. Terracing the soil aids in preventing washing. This is a common practice in Italy, France, Germany and China, and is being used to some extent in the United States.

Courtesy U. S. Department of Agriculture.

FIG. 160. — The kind of land for a woodlot. Timber growing pays better than farming on lands of this character.

2. *Removing plant foods from soils decreases soil fertility.* — Constant cropping of soils and removing the crops reduces the fertility of the soil. Grain and hay crops remove fertility, as indicated in the table on the opposite page.

The ingredients nitrogen, phosphorus and potash are figured at 18, 4.5 and 5 cents per pound respectively, and the manurial value at eighty per cent of the fertility value. We can therefore

see that constantly growing and removing crops from the land will gradually but surely decrease the fertility of the soil.

FERTILIZING CONSTITUENTS PER TON PLANTS AND ANIMALS

	Fertilizing Constituents in One Ton			Fertility Value per Ton	Manurial Value per Ton
	Nitrogen Pounds	Phosphoric Acid Pounds	Potash Pounds		
Dent corn (grain)	32.4	13.8	8.0	$ 6.85	$ 5.48
Wheat	39.6	17.2	10.6	8.83	6.74
Oats	39.6	16.2	11.2	8.42	6.74
Timothy hay	19.9	6.2	27.2	5.20	4.16
Red clover hay	41.0	7.8	32.6	9.36	7.49
Oat straw	11.8	4.2	30.0	3.78	3.02
Corn silage	6.8	3.2	8.8	1.81	1.45
Cotton-seed meal, choice	141.2	53.4	36.2	29.63	23.70
Fat pig	35.4	13.0	2.6	7.10	
Fat ox	46.6	31.0	2.6	9.96	
Milk	11.6	4.0	3.4	2.43	1.94
Butter	2.4	0.8	0.8	0.51	

That continuous cropping reduces soil fertility is shown in the table.[1] The table also shows that rotation helps in protecting the soil to some extent.

ROTATION VS. CONTINUOUS CROPPING IN CROP YIELDS

	Treatment	Average Yield per Acre, Bu.				Average Yield for 20 Years
		1st 5-yr. Period	2d 5-yr. Period	3d 5-yr. Period	4th 5-yr. Period	
Continuously in corn	None	26.26	16.76	10.43	8.44	15.5
Rotation, corn, wheat, clover	None	31.89	30.82	31.04	20.31	29.0

This table, like many others from the experiment stations, shows that continuous cropping reduces the fertility of the soil.

[1] Ohio Station Bulletin No. 282.

Shipping animals from the farm and returning nothing also removes soil fertility. The amount of fertility thus removed is shown in the following table:

SOIL FERTILITY REMOVED PER TON OF ANIMALS REMOVED

	Nitrogen Pounds	Phosphoric Acid, Pounds	Potash Pounds	Fertility Value per Ton
Fat pig	35.4	13.0	2.6	$7.10
Fat ox	46.6	31.0	2.6	9.96
Milk	11.6	4.0	3.4	2.43
Butter	2.4	0.8	0.8	.51

3. *Loss of humus supply as a factor in decreasing soil fertility.* — It has been said that humus is the life of the soil. And since humus comes from organic matter, it is evident, if the organic matter in the form of plants is continuously removed from the soil and none returned, that the soil will soon be very low in humus. This is one way in which humus is removed.

Soils unduly exposed to the hot, drying sun will lose their humus rapidly. A growing crop shading the ground, a cover crop, or a soil mulch will protect the humus content. The air oxidizes the organic matter, and takes out its fertilizing ingredients.

Manures exposed to the weather lose much of their value. At Cornell University manure was exposed from April to September 1st — five months, with the following results.

	Value at Beginning per Ton	Loss per Ton	Loss, Per Cent
Horse manure	$2.80	$1.74	62.0%
Cow manure	2.29	.69	30.0%

One factor in keeping down the fertility of the soil is the careless and wrong methods of handling manures (See chapter on Manures).

The specific gravity of humus is 1.2 to 1.7; that of clay, 2.8; and of sand, 2.6. Humus is only about one-half as heavy as soil, and the particles of humus are also very small. It is therefore evident that humus will be carried off by flowing water before the soil will be carried off. Long before sand and very fine sand are carried off by flowing water, the humus will have been swept on into the fast flowing stream.

The value of humus in improving the soil is discussed in the next chapter.

4. *Soil not able to hold sufficient water, a factor decreasing soil fertility.* — When soils have a tendency to bake and puddle after each rain it is an indication that the structure of the soil is not in good condition, due to a lack of organic matter and lime, and probably to poor drainage. Such a soil will not hold sufficient water, and will not give up the water that it does hold quickly enough for successful plant growth. By the addition of organic matter and lime, by proper drainage and tillage, and by employing a well-arranged system of rotation of crops, such a soil will be greatly improved in yielding its water supply to growing plants.

5. *Loss of nitrogen as a factor in deceasing soil fertility.* — Nitrogen is removed from the soil in four ways: (1) By plants; (2) By water leaching it away; (3) By gaseous evaporation; (4) By denitrification. Growing plants will prevent the leaching away of nitrogen, for the growing plant utilizes it as it becomes available; hence the value of cover crops. The odor one smells in handling fresh manure is ammonia, a compound containing nitrogen. Nitrogen is escaping in the form of ammonia gas.

Denitrification, due to improper drainage or lack of air in the soil, changes the nitrates into nitrites, and sometimes completely into gaseous nitrogen. When nitrogen becomes gaseous or when it is in the form of nitrites, it cannot be used by plants.

6. *Alkali soils as a factor in decreasing soil productiveness.* — The alkali soils occur in sections of the world where there is less than fifteen inches of rainfall. The arid soils of the western part of the United States are alkali to a large extent. And because

of an insufficiency of water percolating through the soil the salt solutions are deposited in the soil. Common salt added to soil lacking drainage will make it alkali.

What effect do the alkali soils have upon plant growth? Just as a piece of potato wilts when put into salt water, so will a plant wilt and finally die in an alkali soil. The salt solution takes a lot of the protoplasm out of the cells with which it comes in contact and this is a sign that osmotic pressure is outward instead of inward, as it is when a plant is growing under normal conditions. How to improve alkali soils will be taken up in the next chapter.

7. *Lack of bacteria in the soil causes it to respond in a decreasing way.* — Soil bacteria require the same conditions for growth that

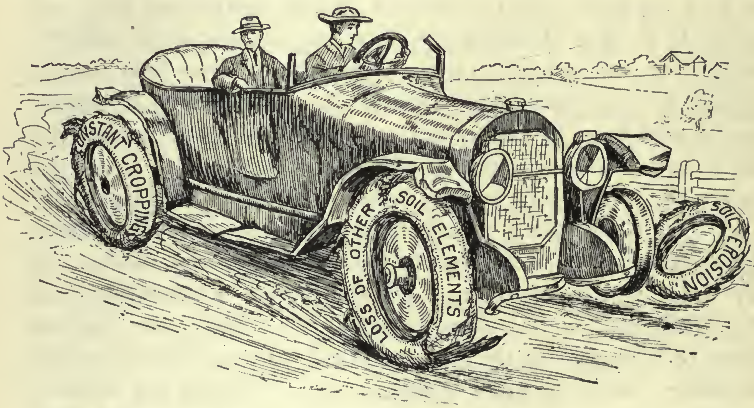

FIG. 161. — How fast soil fertility is lost unless properly husbanded.

any other plants do, for bacteria belong to the plant kingdom. The conditions for their growth are: (1) Food, composed mostly of organic matter in its various steps of decay and putrefaction; (2) Proper temperature — bacteria thrive best at a temperature of 85° to 100° Fahr.; (3) Free oxygen needed by the beneficial bacteria — however, there are bacteria that are anaërobic and live on the oxygen they can secure from their foods; (4) Proper moisture, essential to bacterial life. That is, they prefer such amounts

of moisture as we would find under ordinary field conditions, ranging from fifteen to thirty per cent moisture.

Where there is a lack of bacteria because of an insufficient quantity of food, where the soil is cold on account of an excess of moisture, where air is excluded, or where the soil is too dry or too wet, — we may rest assured that crops will not respond well, for the plant foods that are in the soil are not available. *The soil lacks active fertility* and we must establish conditions in which the soil bacteria thrive or we will likely find the soil *unresponsive.*

Summary. — Although the crop yields in the United States are rather low, contrary to popular opinion they are increasing. These increasing yields are due to better methods of cultivation, seed selection and testing, rotation of crops, etc., rather than to an increased fertility of the soil.

The factors decreasing the fertility of the soil of the United States are: (1) Soil erosion; (2) Removing crops from soils; (3) Loss of humus supply of the soil; (4) Soil in a physical condition so that it will not hold a sufficient amount of water; (5) Loss of nitrogen from the soil; (6) Deposits of water-soluble salts as in the arid sections of the United States, making alkali soils; (7) Lack of soil conditions that foster bacterial growth.

How to combat the factors decreasing soil fertility and how to improve the soil will be treated in the next chapter.

QUESTIONS

1. How does the United States compare with European countries in acreage yields?

2. Which is more important, acreage yield or man yield, and why?

3. What things are conducive to a large man yield?

4. Define soil erosion, and discuss its damages, and how it may be prevented.

5. Name several factors that decrease soil fertility.

6. Why does a ton of red clover remove more soil fertility than a ton of timothy hay?

7. How may humus be lost from the soil?

8. What are the different ways in which nitrogen is lost from the soil?
9. What is the value of bacteria in the soil?
10. Summarize the factors decreasing soil fertility.

PROBLEMS

1. Report upon the topic "Alkali Soils."
2. Report how losses of soil fertility of your locality may be prevented.

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Warren, Elements of Agriculture.
Warren, Farm Management.
Hopkins, Soil Fertility and Permanent Agriculture.

CHAPTER XXIX

FACTORS MAINTAINING AND INCREASING SOIL FERTILITY

Soil saving agencies. — Some of the factors essential to maintaining and increasing the fertility of the soil are: (1) Use of live stock upon the farm; (2) Rotation of crops; (3) Raising legume crops; (4) Keeping up the humus supply; (5) Maintaining good tilth; (6) Preventing erosion; (7) Correcting acidity of the soil; (8) Reducing the amount of alkali in the soil; and (9) Adding plant food by way of manures and fertilizers. The last topic will be discussed in the two succeeding chapters.

1. *Relation of live stock to permanent agriculture.* — The extensive depletion of many farms has been due to the fact that, as Burkett well states — "They sent the fertility away in bushel baskets, in ton lots, in bales, and nothing was returned to the soil." Any soil will become impoverished if crops are constantly being removed and nothing is returned. The following table shows the loss of soil fertility based upon the nitrogen, phosphorus and potash removed.

COMPARED FERTILITY VALUE PER TON OF CROPS AND ANIMAL PRODUCTS

	Nitrogen Pounds	Phosphoric Acid Pounds	Potash Pounds	Fertility Value per Ton	Manurial Value per Ton
Dent corn	32.4	13.8	8.0	$6.85	$5.48
Wheat	39.6	17.2	10.6	8.83	6.74
Red clover hay	41.0	7.8	32.6	9.36	7.49
Fat ox	46.6	31.0	2.6	9.96	
Fat pig	35.4	13.0	2.8	7.10	
Butter	2.4	0.8	0.8	0.51	

Prices of nitrogen, phosphoric acid and potash were estimated at 18.0, 4.5 and 5.0 cents respectively.

At first glance it would appear from the table that live stock remove as much fertility as grains do; but when we recall that it requires from ten to eleven pounds of corn or its equivalent to produce a pound of beef, and from five to six pounds of corn to produce a pound of pork, and when we recall also that about 80 per cent of the fertility ingredients in a feed are returned to the soil in the manure, — that is, out of every five pounds of corn fed to hogs four are returned to the soil, — we readily see the relation of animal husbandry to soil fertility. Burkett in his *Feeding of Farm Animals* makes this excellent statement: "A farmer selling hay sells, in the form of fertilizer value, one-half as much as he received; if he sells pork, he receives twenty times as much for it as the value of the fertilizers contained in it; if milk, forty times; and if butter, one thousand times."

More than that, live stock farming means a diversification of crops, and this protects the fertility of the soil. The value of a variety of crops in systems of rotation will be discussed in the following topic.

2. *Rotation of crops tends to maintain soil fertility.* — No one holds that a mere rotation of crops will maintain or even help to build up or increase the fertility of the soil. For any crop grown and taken off a soil will take with it a certain amount of soil fertility in every ton of plant removed.

But that a rotation of crops protects the soil and serves as a buffer against impoverishment no one questions, for crop yields as shown by experimental evidences all point to the fact that rotation of crops does protect the soil. As proof of the statement, we give the following data, which are representative of many similar experiments.

EXPERIMENTS IN CROP ROTATION[1]

ROTATION	PRESENT YIELD PER ACRE (Corn Yields for 1904)
Corn continuous, 28 years	22 bushels
Corn and oats, 28 years	36 bushels
Corn, oats and clover, 28 years	59 bushels
Pasture 18 years, corn, oats, clover, 10 years	74 bushels

[1] Cir. 96, Illinois Station.

Experiments in Crop Rotation[1]

Rotation	Yield per Acre, 1905
Corn, 17 years	12 bushels
Corn, wheat, clover, 17 years	51 bushels
Corn, oats, wheat, clover, timothy, 17 years	54 bushels
Corn, wheat, clover, 17 years (manured)	78 bushels

In the Illinois experiment, where corn, oats and clover were rotated, the yield was almost three times as much as where corn was grown continuously. In the Missouri experiment, the rotation of corn, wheat, clover with the addition of manure resulted in six and one-half times as large a yield as where corn was grown continuously. In other words, rotation of crops means: (1) We may till less acreage and get as large a yield; (2) Less labor in production, but more harvesting; and (3) The fertility of the soil is protected.

Where rotation of crops is practiced some of the land is protected by grass, some by hay crops, some by deeply penetrating roots, and some by the stubble of harvested wheat and oat fields.

Rotation of crops has the following advantages:

1. Different crops feed at different depths, hence they gather their plant foods from different strata of the soil. This rests the surface soil.

2. Roots growing at different depths of the soil improve the physical condition of the soil, — a very fundamental thing in helping to increase yields.

3. Rotation of crops distributes labor. This gives more time to husband the soil.

4. Decaying roots leave much humus in the soil. Grass lands leave the soil rich in humus, for they restore humus to the soil. It has been found that timothy and red top roots leave 7600 pounds of humus per acre.

5. Rotations help to keep weeds out of the soil, and hence leave the soil in better condition. Insects are also kept out. This

[1] Missouri Station Cir. 38.

helps to increase yields, for it is well known that insects destroy one-tenth of our crops annually.

Remember that every rotation system should include a legume. Remember the rotations above indicated, and the relation to increase of crop production.

3. *The importance of leguminous crops in maintaining and protecting the fertility of the soil* can hardly be overemphasized. To quote Circular 38, Missouri Station: "In ordinary soils only about two-thirds of the nitrogen supply of a clover plant comes from the air, the other third coming from the soil, so that when the tops are removed as hay, one is removing just about the proportion of nitrogen that came from the air, leaving in the root and stubble just about the amount that was taken from the soil. In taking off a clover crop, therefore, one is not building up the soil to any extent in nitrogen but about maintaining it. A man can put nitrogen into his soil through legumes at a cost of from three to six cents per pound, while if he bought the nitrogen commercially it would cost fifteen to eighteen cents per pound. The truck farmer is the only farmer who can afford to use any considerable amount of commercial nitrogen."

The clovers, soy beans, cowpeas and alfalfa, all have deep penetrating roots, as shown in the following figure. This has a renovating effect upon the soil. It opens the soil to percolation, to soil bacteria, to soil air, and all of this is conducive to the best of soil conditions.

As the legumes balance the feed or ration so do they, when rotated with other crops, also balance the conditions controlling the amount of plant foods taken from the soil. Why do crops do well when following a legume? Because the legume has left the soil in a better condition — better physically and chemically.

A ton of manure from the legumes adds more fertility to the soil than does a ton from the cereals. See page 448. Not only are the legumes good feed and renovators of the soil, but when fed make superior manure.

4. *Keeping up the humus supply is an important factor in maintaining the fertility of the soil.* — All soils contain some organic matter in the form of decaying roots, stems, leaves and animal life. The black color of the soil is due to decaying and decayed organic matter. In the last stages of decay this organic matter becomes humus. There is from two to five per cent of organic matter in the average soils — often more in humid regions, and less in arid sections.

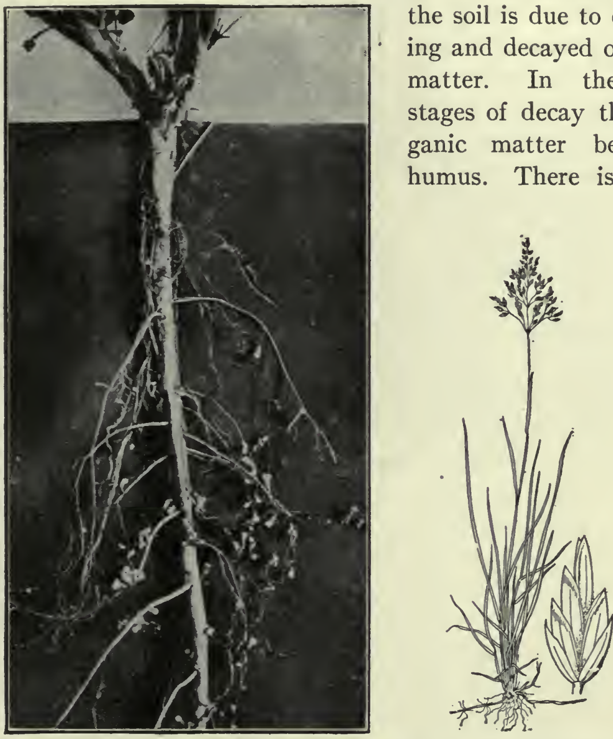

FIG. 162. — Note the rooting habits of grasses and legumes. The grasses have about 80 per cent of their roots in the upper 6 inches of the soil; the legumes have 80 per cent or more of their roots below the surface 6 inches.

Humus improves the soil as nothing else will. It makes a clay soil loose and porous, increases the water holding capacity, prevents soil erosion, provides the best conditions for bacterial life,

promotes chemical reactions, makes available plant foods in the mineral rock particles of the soil, and increases the workability of the soil. Humus is indeed the life of the soil.

The important question is, How may the humus content of the soil be maintained or increased? This may be accomplished by the following practices: (1) Rotation of crops; (2) Cutting wheat, oats, barley several inches higher, and thereby leaving an extra amount of organic matter on the soil in the harvesting process; (3) Adding barnyard manures to the soil; (4) Use of green manure crops; (5) Letting weeds grow on bare spots, and along places where water would erode the soil; and (6) Growing and feeding the legume crops on the farm.

5. *Keeping the soil in good tilth. An important factor in maintaining and increasing soil fertility.* — The factors aiding in improving the tilth of the soil were discussed in a previous chapter. It is well enough to read the discussion again. (See page 396.)

Tilth also increases the organic matter in the soil, for larger crops are produced. It is true that large crops take more plant foods out of the soil. The amount of materials in the cycle of life are simply greater.

Good tilth permits a freer circulation of air and water through the soil, — two essential features in crop yields. A soil in good tilth can be worked earlier in spring and later in the autumn than a soil of poor tilth, — this is an important point in securing good crop yields. Good tilth improves the physical and chemical conditions of the soil. All of these are important factors in plant growth.

6. *Preventing soil erosion is an important factor in maintaining soil fertility.* — Sloping lands are subject to soil erosion and the loss thus wrought is probably the greatest loss of our natural resources. It is important that both people and government should seek to prevent soil erosion. Since this topic was discussed in the previous chapter we shall indicate only one other point in connection with it here.

Nature teaches some of the best lessons. Nature provides means which aid in preventing soil erosion. Nature's vegetation

FIG. 163. A crop of corn and rape sown at last cultivation. Such practice tends to keep up the humus supply.

— grass, weeds, the mosses, and the enormous humus they deposit in the soil — is a wonderful aid in preventing soil erosion. The roots of plants mat the soil together; the deep penetrating roots make large openings in the soil. These large openings are water pipes through which the soil water escapes. The humus of the plants holds the water. Seldom are gullies seen on the steepest hillsides where forests are growing. The decayed leaves act as a sponge in taking up the rainfall. It is this excess water deposited and held in the winter which sustains the fine forests along the steep cliffs in the dry summers. Blue-grass withstands floods and wind storms, holding the soil tenaciously intact. Weeds are not weeds when they are plants holding and improving the soil, for a "weed is a plant out of place," and weeds are not out of place when they are the sentinels and guardians of our soils. Weeds, grass, and trees are our friends, for they are helping in the improvement of our soils.

7. *Correcting the acidity of the soil is an important factor in improving soils.* — There are a good many soils in the humid regions of the United States that are acid or sour. The causes producing acidity in the soil are: (1) Lime is soluble and is therefore easily leached out by drainage water; (2) Lime is taken out of the soil by crops; (3) Some commercial fertilizers are acid; and (4) Green plants when plowed under may cause acidity.

Some plants will not thrive in an acid soil, such as red clover, alfalfa, and blue-grass. In fact, they do best in soils that are slightly alkali. On the other hand, some crops, like the potato, crimson clover, alsike clover, soy beans, cowpeas, blackberries, and red-top are adapted to slightly acid soils.

To detect soil acidity moisten a sample of soil, and insert in it a strip of blue litmus paper. Within twenty minutes, if the soil is acid, the paper will turn red. Soil acidity may be corrected by adding lime to the soil. From one to three tons of ground limestone should be applied to each acre, — depending upon the degree of acidity. Fifty-six pounds of quicklime, and 74 pounds of water-slaked lime is equal to 100 pounds of ground limestone.

In applying lime remember that it is soluble, and may be easily carried away by water. It is better to apply, say, one ton of lime every year, than three tons once in three years. There are lime spreaders on the market, which may be purchased co-operatively by several farmers of a community, and they will be found more satisfactory in distributing the lime. However, lime may be scattered broadcast.

FIG. 164. — A lime spreader, spreading ground limestone. The lime is evenly and uniformly distributed.

The beneficial effects of applying lime to the soil, other than correcting acidity, are: (1) Lime improves the physical condition of the soil. It flocculates the soil particles; that is, lime causes them to group themselves into little clusters. It is said that one part of lime will flocculate and clear ten thousand parts of muddy water. Since the surface six inches of an acre of soil weighs about nine hundred tons, it is evident that one ton of lime will readily flocculate the soil particles of the average acre of land. (2) Lime or calcium is itself an essential plant food, which frequently is lacking in the soil. Most soils, however, have sufficient lime for crop growth. (3) Lime helps to unlock other plant foods, especially potassium and phosphorus. In this capacity lime is a very valuable soil amendment. (4) Lime aids in the chemical and bacterial processes in the soil. Bacterial life is fostered by lime, and the processes underlying nitrification demand a neutral, sweet soil.

8. *Removing the alkali from soils a factor in improving the fertility of the soil.* — The most satisfactory way of removing the alkali is by underdrainage. Heavy applications of water are passed over the alkali soil, and the salts are carried off by the water through underground tiles. The natural rainfall will also leach away the salts if tiles are provided to carry off the water. This is especially true where there is considerable rainfall.

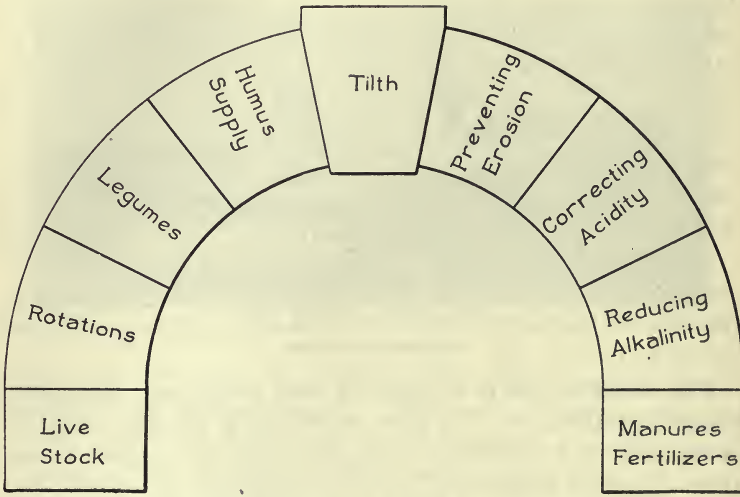

FIG. 165. — The Arch of Soil Fertility. Each factor of soil fertility should be studied in order that the soil may be handed down to future generations in the best of condition. Support the arch of Soil Fertility that our people may remain prosperous.

Summary. — Permanent agriculture is dependent upon the fertility of the soil. It behooves us to husband the soil. Let us leave it richer than we found it, in order that oncoming generations may have a better chance to "grow two blades of grass where only one grew before."

Some of the factors essential to maintaining and increasing the fertility of the soil are: (1) Use of live stock upon the farm; (2) Rotation of crops; (3) Raising leguminous crops; (4) Keeping up the humus supply of the soil; (5) Maintaining good tilth;

(6) Preventing soil erosion; (7) Correcting the acidity of the soil; (8) Reducing alkalinity of the soil; and (9) Adding plant food in the form of manures and commercial fertilizers.

QUESTIONS

1. What are the factors essential to maintaining and increasing the fertility of the soil?
2. How does animal husbandry farming help in maintaining soil fertility?
3. Discuss all the advantages of crop rotation.
4. Give some concrete data showing that crop rotation helps to maintain larger yields.
5. Name the legume crops and discuss them as protectors of the soil.
6. Define tilth.
7. Suggest how to prevent soil erosion.
8. How may soil acidity be corrected? How would you determine whether a soil is acid or not?
9. In what part of the United States are the alkali soils mostly found?
10. Suggest some other points besides those mentioned in this chapter which will help in restoring and increasing soil fertility.

PROBLEMS

1. Discuss the natural vegetation as a factor in protecting and maintaining soil fertility.
2. Discuss fully with specific illustration Burkett's statement found on the first page of this chapter.

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Gehrs, Productive Agriculture.
Whitson and Walster, Soils and Soil Fertility.
Vivian, First Principles of Soil Fertility.
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Warren, Farm Management.

CHAPTER XXX

BARNYARD MANURE

Importance of manure. — The value of manure has not been fully realized in the United States. We do not realize what an immense amount of manure is produced, how it may be handled to good advantage, and how losses of plant foods may be prevented.

The value of manures in comparison with four of our important farm crops is indicated by the following graph:[1]

Manure . . .	$2,000,000,000
Corn	1,755,859,000
Wheat . . .	930,302,000
Oats	655,569,000

Each farm animal produces annually from eight to fifteen times its own weight of manure. The following table shows the number of farm animals in the United States in 1916; and the estimated value of manure produced:

Number of Animals and Approximate Value of Manure

	Number of Animals	Value of Manure per Each Animal	Total Value
Horses	21,000,000	$27.00	$ 571,293,000
Mules	4,593,000	27.00	124,000,000
All cattle	61,930,000	20.00	1,272,340,000
Sheep	48,625,000	2.00	96,966,000
Swine	67,766,000	8.00	539,624,000
Grand Total . . .			$2,604,223,000

[1] Data 1915.

The value of the manure produced annually in the United States equals the combined sales from poultry, sheep, swine, and dairy cattle.

Composition of manure. — Since the amount of dry matter and the nitrogen, phosphoric acid, and potash content determine largely the fertility value of a manure, let us see what the composition of manure from different animals is.

COMPOSITION AND VALUE PER TON OF AVERAGE MANURE FROM FARM ANIMALS

	Water, Per Cent	Nitrogen Pounds	Phosphoric Acid, Pounds	Potash Pounds	Value in Dollars
Sheep	68	19	7	20	$4.74
Horse	78	14	5	11	3.30
Cow	86	12	3	9	2.74
Pig	87	10	7	8	2.52
Chicken	88	32	32	16	7.92

Sheep and horse manure have a smaller water content. Poultry manure on account of its composition has the greatest fertility value; sheep manure is second in value. The plant foods, nitrogen, phosphoric acid and potash, are figured at 18.0, 4.5 and 4.5 cents per pound respectively.

The amount of manure produced by each farm animal per one thousand pounds live weight is about as follows:

AMOUNT OF MANURE PRODUCED PER 1000 POUNDS LIVE WEIGHT

	Excrement per Year Tons	Manure with Bedding per Year Tons	Nitrogen per Year Pounds	Phosphoric Acid per Year Pounds	Potash per Year Pounds	Cost of Elements if Purchased in Commercial Fertilizers
Horse	8.9	12.1	153	81	150	$33.72
Cow	13.5	14.6	137	92	140	31.20
Sheep	6.2	9.6	175	88	133	36.84
Calf	12.4	14.8	150	105	102	32.28
Pig	15.3	18.0	331	158	130	64.48
Fowl	4.3	4.3	302	119	72	54.52

Factors affecting the composition of manures. — The principal factors affecting the composition and value of manures are: (1) Kind of feed; (2) Age of animal; (3) Kind of animal; (4) Kind of bedding; and (5) The care taken of the manure.

1. It is evident that a ton of dent corn has a greater manurial value than a ton of timothy hay. A ton of corn cobs, corn fodder, corn silage, or sawdust does not add much soil fertility; but a ton of cotton-seed meal, bran, tankage, or alfalfa hay has considerable manurial value. The following table indicates the fertilizing ingredients and manurial value of different feeds.

Comparison by Fertility and Manurial Value of Different Feeds

	Nitrogen Pounds	Phosphorus Acid, Pounds	Potash Pounds	Fertility Value	Manurial Value
Cotton-seed meal	141.2	57.4	36.2	$29.63	$23.70
Tankage . . .	129.2	271.4	0.0	35.23	28.18
Bran	51.2	59.0	32.4	13.49	10.79
Alfalfa hay . .	47.6	10.8	44.6	11.00	8.84
Corn silage . .	6.8	3.2	8.8	1.81	1.45
Oat straw . .	11.8	4.2	30.0	3.78	3.02
Timothy hay .	19.8	6.2	27.2	5.20	4.16

About 80 per cent of the fertilizing ingredients in feeds is recovered in the manure. The feeding value and fertility value are in almost direct proportion. The fertility value of a feed may sometimes be the factor which should determine what feed is to be purchased.

2. The age of animals affects to a considerable extent the manurial value of a feed. Young animals are more capable of digesting feeds than are old ones. Old animals with poor teeth have low powers of digestion. Dean Henry states that a young calf digests about 70 per cent of the nitrogen in its feed and 46 per cent of the ash materials, while a milch cow uses only 25 per cent of the nitrogen fed her, and 11 per cent of the ash. Young animals put on pounds much more rapidly with less feed than old animals. One reason for this is that they digest more of their food.

3. The kind of animal affects to some extent the fertilizing ingredients of the manure, although the mere passage of feeds through the digestive process does not add any value to the manurial product. It may be seen from the previous table that poultry or sheep manure is richer than horse, cow, or pig manure.

4. The kind of bedding used affects the value of manures. Sawdust, wood shavings and corn fodder do not add much fertility; but oat straw, wheat straw, leaves, any of the wasted leguminous hays, add more fertility. Bedding does more than add so much fertility. It absorbs the liquid portion of the manure and thus makes it possible to return liquid fertilizers to the soil.

5. The care taken of the manure has an important bearing upon its retaining its manurial value. This topic will be discussed in a later paragraph.

Relative value of liquid and solid manure. — The composition of the liquid and solid parts of manure is quite different. The liquid part contains much more nitrogen and potash than does the solid part, but the solid part contains the greater part of the phosphoric acid. The relative composition of the solid and liquid portions is as follows:

RELATIVE VALUE OF SOLID AND LIQUID MEASURE

		Nitrogen Per Cent	Phosphoric Acid Per Cent	Potash Per Cent	Value per Ton Per Cent
Horse	Liquid manure . .	1.52	0.0	0.92	$7.00
	Solid manure . .	0.56	0.35	0.10	2.69
Cow	Liquid manure . .	1.05	0.0	1.36	5.56
	Solid manure . .	0.44	0.12	0.04	1.92

Liquid manure is worth about three times as much as solid manure. Although the liquid excrement is only about one-third as much as the solid portion, its fertilizing value is more than equal to that of the solid portion. The liquid manures are often lost. Such bedding as will absorb the liquid portion of the manure should be used. Straw and leaves are good absorbers and help

especially to conserve the nitrogen which is abundant in liquid manure.

Losses of manure. — Manures are lost principally in four ways: (1) By leaching; (2) By fermentation; (3) By open lot feeding; and (4) By piling manures in heaps in fields.

1. The liquid portions of manure are easily lost through leaching. Phosphoric acid and potassium are also leached out to some extent.

2. Fermentation is another source of loss of manures. It has been proved that from 30 to 60 per cent of the nitrogen of manures may be lost by fermentation. The odor about horse stables is

FIG. 166. — To feed cattle in this way is a wasteful practice.

due to ammonia gas escaping. Ammonia contains nitrogen, the element lost by fermentation. Covered manure sheds aid greatly in preventing fermentations. Keeping the manure wet also prevents fermentation.

3. Open lot feeding, unless carried on over a large area, is a wasteful practice from the standpoint of feeding as well as from the standpoint of the loss of manure.

4. Piling manure in heaps in fields and under eaves of barns is a common practice, but a very wasteful one. Professor Thorne, of the Ohio Station, says, "Of all the ways by which manure is handled, piling it in heaps in the field is the most wasteful."

How to conserve manure. — If the different authorities are correct that by the present method of handling manures over 50 per cent of all manures are wasted (or $1,302,000,000 annually), then it behooves us to consider how this important plant food may be kept and conserved.

The best way to get the full value from manure is by hauling and scattering it over the land as soon as it is produced. This will do more to conserve all the plant foods in it than any other single factor. This method requires less labor, keeps the premises clean, and helps in conserving the maximum amount of plant food.

If manure cannot be hauled out soon after it is produced, then it is best to use sufficient bedding in the form of straw to absorb

FIG. 167. — A common method of handling manure. Leaching and fermentation will remove half of its plant foods in six months. It is like burning money.

the liquid part of the manure. Covered sheds and barnyards help in conserving the plant foods in manure.

Reënforcing of manures. — Barnyard manures are somewhat deficient in phosphorus, in proportion to the nitrogen and potassium content. It is for this reason that manures are often reënforced with 50 to 100 pounds of acid or rock phosphate per ton of manure. This has brought good net returns in various places.

The following table[1] is a representative table showing the value of the reënforcement of manure with phosphates.

VALUE OF REËNFORCED MANURE WITH PHOSPHATES

Average for 18 Years

	CORN BUSHELS	WHEAT BUSHELS	HAY TONS	VALUE OF THREE CROPS	NET GAINS FOR PHOSPHATE FROM $1.00 EXPENDED
None	34.7	11.6	1.37	$29.85	
Manure	56.4	21.2	1.91	47.95	
Manure and rock phosphate . . .	65.2	25.8	2.36	57.40	$4.91
Manure and acid phosphate . . .	64.0	26.7	2.34	57.47	3.25

From the table it may be observed that a phosphate fertilizer added to barnyard manure improves its productive ability by a

Courtesy Wisconsin Station.

FIG. 168. — Manure versus manure with rock phosphate. The use of rock phosphate in addition to farm manure increased yield 47 per cent.

fair margin of profit per every dollar spent for rock or acid phosphate.

[1] Ohio Station, Circular 104.

Not only should manures be reënforced by phosphates but by bedding and litter as well. Manure must be reënforced by the intelligence of man if it is to do the most efficient service of unlocking plant foods in the soil.

Application of manure. — Manure is most evenly distributed by a manure spreader, and a thin application well distributed is the best way to get the most out of manure. Two applications of six tons to the acre three years apart bring larger returns than a single application of twelve tons. Five tons of manure is a

Courtesy International Harvester.

FIG. 169. — A manure spreader. The manure is handled only once, and is evenly distributed.

light application; ten tons, a moderate application; and twenty tons, a heavy application.

If manure cannot be distributed when produced, it is best to spread it in the spring of the year, and then plow it under. Manure applied to truck crops, and to the soils of greater fertility, usually brings better returns. A ton of manure applied to a poor soil will not bring as much profit as when applied to a rich soil.

Benefits of manure. — Manure benefits the soil in many ways: (1) It increases the supply of organic matter in the soil. The addition of 8 or 10 tons of manure to an acre increases the organic

and humus content materially. The humus made from manure has all the good effects upon the soil that were accredited to humus in a previous chapter: (2) Manure adds plant foods. Besides nitrogen, phosphorus, and potassium, the other elements found in plants are thus turned back to the soil. Van Slyke says, "When it is kept in mind that about 80 per cent of the plant food constituents of the food of animals can be found in the manure, it is readily appreciated that the crops raised on a farm and fed to animals belonging to the same farm do not constitute such an exhausting drain on fertility as when crops are removed from the farm." (3) Manure aids in increasing the activity of the bacteria in the soil. These, plus chemical reactions, help to make plant foods available for plant growth. (4) Manure tends to make the soil warm. Its addition aids then in prolonging the season, giving plants an early start, a point which is very essential in securing the largest yields. This is especially true in the case of oats, truck, and grass crops. (5) The addition of manure prevents soil erosion. It binds a sandy soil together and prevents erosion. It loosens a clay soil, which aids percolation, an essential point in preventing soil erosion. (6) Manures aid in increasing and controlling soil water. As was indicated in a previous chapter, humus has about four times the water holding capacity that clay has; and, therefore, its addition to the soil increases the water holding capacity. A soil with an average amount of well-decayed organic matter does not dry out as easily as one depleted of organic matter. (7) The good effects of manure may be seen for several years, and its value as a factor in crop production is well substantiated the world over. The specific value of manure in increasing yields will be emphasized in the next paragraph.

Value of manure in crop production. — Although the value of manure is figured at the current prices of nitrogen, phosphoric acid and potassium as in commercial fertilizer, yet it is probably better to figure its value upon the basis of its producing power. If a ton of manure will produce an additional 50 pounds of wheat the first year, 30 pounds the second year, and 20 pounds the

third year, then the manure may be accredited with 100 pounds of wheat. If wheat is worth two cents per pound, then the manure was worth $2.00 per ton. This is probably putting the figures too low but it serves for the illustration.

It is commonly supposed that manure will yield up its plant foods 50, 30, and 20 per cent respectively for each of the first three years, but manure affects the yield for a much longer period than three years. The lasting effect of manure is well brought out by an experiment at the Rothamstead Station England. The experiment extended over 40 years. One plot of ground was manured yearly the first twenty years. Another plot received no treatment. Then both plots were sown to barley yearly for 20 years. The following table shows the results.[1]

LASTING EFFECT OF BARNYARD MANURE ON CROP YIELDS

AVERAGE YIELD 5 YEAR PERIODS	UNMANURED EVERY YEAR	LASTING EFFECT OF BARNYARD MANURE
First 5 years	13 bushels	39 bushels
Second 5 years	14 bushels	29 bushels
Third 5 years	14 bushels	30 bushels
Fourth 5 years	12 bushels	23 bushels
Average 20 years	13.25 bushels	30 bushels

The plot manured the first twenty years of the experiment but not during the last twenty yielded 600 bushels of barley; but the other plot that was not manured yielded only 301 bushels. The experiment clearly demonstrates the fact that barnyard manures have a lasting effect upon crop production. The illustration is also a good one to show the relation of manure to increase in crop production.

The effect of manure upon timothy hay production is indicated by the following figure.

The value of manure in corn, wheat and oat production over a long period is shown in the following table:

[1] Ohio Station, Bulletin No. 246.

PRODUCING POWER OF MANURE

	TONS OF MANURE APPLIED PER ACRE	MANURED	NOT MANURED
Corn, duration of test 17 years	$2\frac{1}{2}$ tons	27.97 bushels	16.87 bushels
Wheat, duration of test 17 years	5 tons	18.36 bushels	8.21 bushels
Oats, duration of test 17 years	5 tons	38.67 bushels	23.45 bushels

Each of the above crops was grown continuously on the same plots. The data clearly show the effect manure has in increasing the yields, causing corn to yield an average of 11.10 bushels more per acre for each of seventeen years; wheat 10.15 bushels more; and

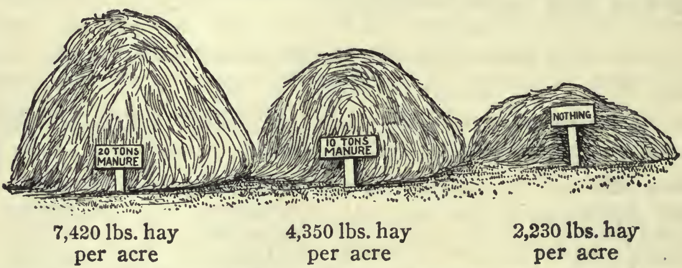

FIG. 170. — The above figure shows the effect of manures on hay production.

oats 15.22 bushels more. These increases give manure a definite money value according to the current prices of corn, wheat and oats.

Cyril G. Hopkins, in his book entitled *Soil Fertility and Permanent Agriculture*, has given the following excellent advice regarding the use of manure:

"In the author's opinion, the crop rotation in live stock farming should be so planned that there is always a place to haul and spread manure, and so that every cultivated field is covered with manure at least once during each rotation, the manure being spread lightly or heavily in accordance with the annual supply and the size of the field to be covered; and, if necessary, in order to maintain the humus and nitrogen content of the soil, the farm manure should be supplemented by plowing under clover or other

legumes, keeping in mind that one ton of clover hay plowed under is equivalent to four tons of average fresh manure, and that many can grow clover who cannot produce sufficient manure."

Green crop manures. — Crops are sometimes grown for the purpose of plowing them under. Such leguminous crops as red clover, alfalfa, soy beans, cowpeas, alsike clover, white clover, vetch and rape, and such grasses as barley, rye, wheat and oats may be grown as a cover crop, used in the fall, winter and spring, and then plowed under. The legumes have the special value of deep penetrating roots and of depositing atmospheric nitrogen in the soil. The grasses protect the soil and furnish a great deal of pasture.

Van Slyke, *Fertilizers and Crops*, assigns the following beneficial effects to green crop manures: "(1) They add organic matter; (2) Conserve soluble plant food; (3) Add nitrogen to the soil; (4) Transfer plant foods from subsoil to the surface soil; (5) Have a good effect on the bacterial life of the soil; (6) Increase the plant foods; (7) Improve the subsoil; (8) Protect the surface soil; and (9) Improve the structure of the soil."

Green manure crops may be used to protect hillsides from erosion through the fall, winter, and spring. Cover crops protect and absorb the soluble plant foods in the soil. Soils that are depleted of nitrogen may be improved in that element by a legume cover crop. Soils that are poor in tilth may be helped by the use of green manure crops. Green manure crops increase the yields of succeeding crops. Crops that are worth harvesting should not be plowed under, but should be fed to some farm animals and the manure returned to the soil.

Summary. — The value of barnyard manure is not properly appreciated. Its composition is such that it is worth ordinarily from two to three dollars per ton for crop production. Poultry or sheep manure carries more fertility than does horse, cow, or pig manure. The factors affecting the value of manure are: (1) Kind of feed used; (2) The age of animals; (3) Kind of animal; (4) Kind of bedding; and (5) Care of manure. Liquid manure contains half of the fertility value of the excreta of animals; hence

it should be carefully conserved by use of good absorbing bedding. Manures are lost by: (1) Leaching; (2) Fermentation; (3) Open lot feeding; and (4) Piling manures in heaps in fields.

Manures are best conserved by hauling them out and distributing them evenly with a manure spreader as soon as they are produced. Manures are reënforced by the use of phosphates, good bedding and intelligent farming. The benefits of manure are inestimable. They help in increasing crop yields and at the same time reduce the cost of production, per bushel or per ton of product produced. Manures have a lasting effect upon the productivity of the soil.

Green manure crops of the grass and legume kind affect the soil favorably, and experiments have clearly shown that their more extensive use may be safely recommended.

QUESTIONS

1. What is the relative money value of manure compared with five farm products?

2. What are the valuable elements in manures? What is each worth at the present time when purchased in commercial fertilizers?

3. Discuss the factors which affect the composition and value of barnyard manures.

4. What elements found in liquid manure make it of great value? How may liquid manure be preserved?

5. In what ways are manures lost? How may these losses be prevented?

6. Discuss the handling of manures.

7. What is meant by reënforcing manures?

8. Discuss the various benefits of manures.

9. How do you estimate the value of manures?

10. What are some excellent crops adaptable as green manure crops? And why?

PROBLEMS

1. Compare the value of the manurial product of the animals of your state with the expenditures for running the state government, the schools.

2. Estimate the value of all manures produced upon a certain farm.

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Henry and Morrison, Feeds and Feeding.

CHAPTER XXXI

COMMERCIAL FERTILIZERS

Decrease in soil fertility. — Taking crops and animals from the farm decreases soil fertility, though the amount of plant foods in the soil is fortunately large. The composition of four kinds of soils is shown in the following table:

POUNDS OF PLANT FOOD PER SURFACE FOOT IN AN ACRE

KINDS OF SOIL	NITROGEN	PHOSPHORIC ACID	POTASH
Peat	11,965	550	1,697
Sand	1,675	620	39,750
Clay	3,250	5600	12,600
Black loam clay	12,360	5720	67,730

An acre of sandy soil contains 1675 pounds of nitrogen, 620 pounds of phosphoric acid and 39,750 pounds of potash. A ton of wheat removes 39.6 pounds nitrogen, 17.2 pounds of phosphoric acid and 10.6 pounds potash. How many crops of wheat could be grown upon a sandy soil of the above composition? There is enough nitrogen to yield (1675 ÷ 39.6 lb.) 42 crops; enough phosphoric acid to produce (620 ÷ 17.2 lb.) 36 crops; and enough potassium to produce (31,750 ÷ 10.6 lb.) 3750 crops. The average number of crops that could be produced far exceeds the estimate given, for the average farm land has a richer and a more balanced composition than any of the soils above named.

It behooves the farmer to take a maximum amount of plant food from the soil by way of crops and live stock; and know how the fertility of the soil is to be maintained so that he may continue

to take off large crops. This is important for the welfare and prosperity of our people.

It is thought by some that the use of commercial fertilizers will maintain the fertility of the soil. Others believe that the present careless use of commercial fertilizers should be thoroughly investigated. It is the purpose of this chapter to stimulate rational thinking regarding the purchase and use of commercial fertilizers.

Commercial fertilizers only a drop in the bucket. — How much plant food is usually added by way of commercial fertilizers per acre? If 200 pounds of fertilizers containing 0.8 per cent available nitrogen, 8 per cent available phosphorus and 2 per cent available potash were added, there would be added 1.6 pounds of nitrogen, 16.0 pounds of phosphoric acid, and 4.0 pounds of potash to the acre. This amount of plant food added to any kind of soil adds only an insignificant trifle of plant foods to those that are already in the soils, as the table in the preceding paragraph clearly indicates.

Again, if we compare the amount added of each element in the fertilizer with the amount removed by a crop, we find similar results. This is especially true of the nitrogen. The addition of 200 pounds of such a fertilizer adds only a small per cent of the nitrogen taken out by a ton of dent corn. There would be added 1.6 pounds of nitrogen and a ton of corn removes 32.4 pounds. (See table, page 472.) Therefore, we cannot attribute the additional yields to any extent to the nitrogen in the fertilizer.

If the 200 pounds of fertilizer adds 16.0 pounds of phosphoric acid, and corn removes only 13.8 pounds per ton, the amount of phosphoric acid added equals approximately the amount of phosphorus removed. The 200 pounds of fertilizer described adds only 4 pounds of potash, which is about one-fourth of what a ton of corn removes per acre.

If such a fertilizer does any good at all, it must be due to the phosphoric acid, and not to the potash, for the potash was approximately only one-fourth of what the crop needed yearly. That

the use of phosphoric acid in crop production has given economic returns is substantiated by extensive experimental evidence. The use of nitrogen and potash has not given such good returns; although exceptions to the statement may be quoted by people who are interested more in commercial sales than in economic crop yields.

The essential elements of a fertilizer. — The elements nitrogen, phosphorus and potash are the valuable ingredients of the soil; for they are found in smaller quantities in proportion to their needs, and are also more easily lost, than some of the other elements. Their price fluctuates as anything else does, but the value of nitrogen, phosphoric acid and potassium is figured at 18, 4.5 and 4.5 cents per pound respectively in all tables of this chapter. And that is about what they are estimated at in commercial fertilizers.

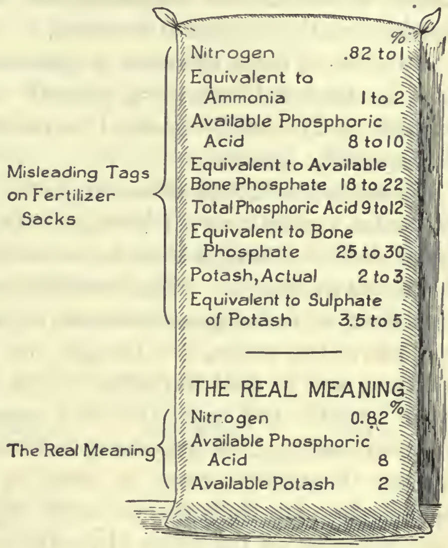

FIG. 171. — Misrepresentation.

All other elements, besides nitrogen, phosphorus and potassium, named on fertilizer bags and by agents selling commercial fertilizer have no value except as a filler. The misleading information on fertilizer sacks is indicated in the above figure.

This fertilizer contains .82 per cent available nitrogen, 8 per cent available phosphoric acid, and 2 per cent available potash. If these elements are worth 18, 4.5, and 4.5 cents per pound respectively, it can soon be figured what such a fertilizer is worth,

and what it adds to the soil when applied. All other talk outside of the three elements named is misleading. Every fertilizer sack should be labeled properly. It is to be hoped that more sensible laws regulating the manufacture and sale of commercial fertilizers may be enacted and enforced. A statement of James J. Hill, president of the Great Northern Railroad, is applicable. This statement is, "The farm is the basis of all industry, but for many years this country has made the mistake of unduly assisting manufacture, commerce, and other activities that center in cities, at the expense of the farm."

Function of these elements in plant and animal growth. — This can be answered only in a general way here. Although each element is absolutely essential to plant or animal growth, each has a specific function.

Nitrogen promotes leafiness in plants. Green, luxuriant growth indicates a sufficiency of nitrogen. Often orchard trees have a great deal of foliage, which shows that an abundance of nitrogen is present in the soil. Phosphorus is found in some of the proteins, and since we find a greater amount of protein in the seeds than in the leaves and stems, it is thought that phosphorus plays an important part in seed formation. This element hastens root and stem growth, and especially seed growth, and for that reason hastens maturity, an important factor often in getting maximum yields. Potassium seems to assist in the formation of starch and sugar. Dr. Hall, director of the Rothamsted Station, reports the following on the effect of potassium on leaf, root and sugar production in mangels.

THE EFFECT OF POTASSIUM ON THE PRODUCTION OF MANGELS

	Leaf per Acre	Roots per Acre	Sugar per Acre
Ammonia, salts and phosphates applied	2.95 tons	12.00 tons	.8 ton
Ammonia, salts, phosphorus and potassium applied	3.25 tons	28.95 tons	2.2 tons

The sugar content more than doubled when potassium was applied.

In animal bodies, nitrogen helps in making bone, tendons, muscles and other tissues. Phosphorus makes up a large part of the bones, ninety per cent of the bones being lime and phosphorus. Potassium aids also in bone formation and other processes.

Kinds of commercial fertilizers. — Just as there are three essential elements in fertilizers, so there are, broadly speaking, three kinds of fertilizers. Each is named for the element which makes up the main ingredient, and hence we have nitrogenous, phosphatic and potassium fertilizers.

Nitrogenous fertilizers. — The chief sources of nitrogenous fertilizers are: (1) Slaughterhouses; (2) Sodium nitrate mines; and (3) Cotton-seed factories. Dried blood, tankage, and steamed bone meal come from the slaughter houses. Sodium nitrate, or Chile saltpeter, is mined in Chile and Peru. Cotton-seed meal comes from the factories where the oil is extracted from the cotton seed. These nitrogenous fertilizers often contain some phosphorus and potassium. Their composition varies but is about as follows:

Composition of Fertilizers per Ton

	Nitrogen Pounds	Phosphorus Pounds	Potash Pounds
Dried blood	260–280	10–20	0.0
Tankage	80–240	30–120	0.0
Steamed bone meal	20–30	560–600	0.0
Sodium nitrate	300	0.0	0.0
Cotton-seed meal	140	20–40	0.0

While it sometimes may become necessary to apply nitrogenous fertilizers, the cheapest and most effective means of increasing the nitrogen in the soil is by the growing of legume crops. Occasionally such a crop may be plowed under. The tops of legumes are richer in plant foods than the roots. The composition of the red clover plant follows:

	Nitrogen Per Cent	Phosphorus Per Cent	Potash Per Cent
Tops	68	65	82
Roots	32	35	18

Hopkins says: "The legumes do not gather enough nitrogen from the air to add an appreciable amount of nitrogen to the soil where the crops are annually removed. Unless some legume is plowed under, the balance in nitrogen may be maintained by the growing of a legume, but not increased. Consequently, manure, a legume crop, or commercial nitrogen must be added if it is to be increased in the soil."

Phosphate fertilizers come from phosphate rocks and slaughter-houses. The deposits of rock phosphates in the United States are rather large. Florida, South Carolina, Tennessee, Utah, Idaho and various other states are underlaid with rock phosphate. The rocks are ground into fine powder, and the product is sold under the name "Floats, or Rock Phosphate." The bones of animals slaughtered in the packing houses are made into fertilizers. The amount of phosphorus in the bones of animal bodies ranges from 6 to 10 pounds per 1000 pounds of live weight. About 750,000 tons of phosphorus fertilizers are made annually from the bones of farm animals. The phosphorus content of these fertilizers ranges from 10 to 25 per cent; the average being probably 12½ to 15 per cent soluble phosphorus. The rock phosphates contain from 20 to 30 per cent phosphoric acid.

Composition of Phosphate Fertilizers per Ton

	Nitrogen Pounds	Phosphorus Pounds	Potash Pounds
Pure bone meal . . .	40–50	480–500	0.0
Pure raw bone meal . .	60–70	460–480	0.0
Rock phosphate . . .	0.0	240–260	0.0

The phosphate fertilizers are probably the most important fertilizers on the market, considering their price and their value in growing plants. Available phosphorus in commercial fertilizers was worth about 6 cents per pound in Missouri in 1916. Hopkins states: "Phosphorus is the only element that must be purchased and returned to the most common soils of the United States. Phosphorus is the key to permanent agriculture. To maintain or to increase the amount of phosphorus in the soil makes possible the growth of clover or other legumes and the consequent addition of nitrogen from the inexhaustible supply in the air." Many experiments at Rothamsted, England, and others in Ohio, Pennsylvania, Illinois and Louisiana, all substantiate the statement that crops produced upon lands fertilized with phosphorus yield a greater net profit than lands to which expensive nitrogenous fertilizers are applied.

Potassium fertilizers are supplied by the Stassfurt mines in Germany. Most soils of the United States are relatively rich in the potassium content, and therefore this ingredient is not frequently lacking. Furthermore, potassium is rather insoluble, and in that way nature has kindly protected this valuable plant food for us.

What fertilizer to use. — To determine what fertilizers are needed by a given soil: (1) Write to your Agricultural College; (2) Read the best literature on the subject; and (3) Experiment as shown in the following plan. Each plot is one rod wide by eight rods long, and contains $\frac{1}{20}$ of an acre.

PLAN OF PLOTS, SHOWING HOW FERTILIZER EXPERIMENTS MAY BE CARRIED OUT

No fertilizer.	No fertilizer.
15 pounds of nitrogen fertilizer.	15 pounds of phosphoric fertilizer.
15 pounds of nitrogen fertilizer. 15 pounds of phosphoric acid.	15 pounds of phosphoric acid. 15 pounds of potash.
15 pounds of nitrogen fertilizer. 15 pounds of phosphoric acid. 15 pounds of potash.	15 pounds of potash. 150 pounds of lime.

Such an experiment will indicate to some extent the judicious use of commercial fertilizers especially if crops are planted across the plots. No drastic conclusions should be made from this little farm experiment, for seasons, conditions and crops vary with different years.

Home mixing of fertilizers. — Complete fertilizers contain three elements: nitrogen, phosphorus and potassium. A 2–8–4 fertilizer presumably contains 2 per cent nitrogen, 8 per cent phosphorus and 4 per cent potassium. Complete fertilizers should ordinarily not be bought, but the elements making up such a fertilizer may be bought. This practice has the following advantages: (1) By using the elements we may soon determine what elements are needed, but in a complete fertilizer we cannot determine what element is bringing economic returns. (2) It is useless to waste money on three elements when one of the three will bring as good results. (3) The unmixed elements can usually be purchased at a lower cost than when they are mixed. Chicken feeds, condimental and proprietary feeds, often cost several times as much per pound as do the single ingredients in the feed. Oats, corn, wheat and kafir when mixed were priced at $4\frac{1}{2}$ cents per pound, when the highest one was priced at $1\frac{3}{4}$ cents. (4) Home mixing of commercial fertilizers is educative. Complete fertilizers are perplexing.

Application of fertilizer. — If commercial fertilizers are used it may be well to employ the following suggestions:

1. The fertilizer should be placed in the hill where the plant is to grow, so that it may be used the same season; otherwise much of it may leach away.

2. Commercial fertilizers bring better returns on rich than on poor soils. Warren states: "It does not pay to put commercial fertilizer on poor land. Such land usually needs humus, and must be treated before it will pay to use fertilizers. About forty farmers in New York have reported trials of nitrate of soda for the production of timothy hay. In very few cases has it paid if the field did not yield at least one and one-fourth tons when un-

treated, and in very few cases has it failed to pay when the unfertilized acre yielded over one and one-fourth tons. It seems to be very nearly as easy to double a yield of one and one-half tons as to double a yield of one-half ton. In the former case the gain will be three times as much as in the latter."

3. The use of commercial fertilizer may pay well in truck farming. That is, if the value of the crop is $100 to $200, a ton of fertilizer, the price of which is $30.00, may yield $20.00 of net profit. If the same amount of fertilizer were applied on poor soils on an oat or timothy crop, the loss would likely be about $20.00.

4. It should also be remembered that farm manures add plant foods most cheaply. The composition of farm manures is about as follows:

Composition, Price and Producing Value of a Ton of Manure and Commercial Fertilizer

	Potash Pounds	Nitrogen Pounds	Phosphoric Acid Pounds	Usual Price Estimated	Usual Value Crop Yields Estimated
Average farm manure . .	16	16	8	$ 0.50	$ 2.50
A 2–8–4 fertilizer	80	40	160	20.00	25.00

Barnyard manures, green manure crops, the use of legumes and crop rotations are the easiest and cheapest means of maintaining soil fertility.

Commercial fertilizers not all-sufficient. — The fact is, commercial fertilizers are *insufficient*. We must turn to other farm practices than the use of commercial fertilizers if our soils are to be maintained in their present state of fertility. Let us quote a few statements from some of the best authorities on permanent agriculture. Vivian says, "Notwithstanding the fact that commercial fertilizers have an important place in rural economics, they should not be used to do the work that can be better accomplished by properly husbanding the home resources."

Warren states in *Farm Management:* "Of course, the nitrogen supply may be maintained by the addition of farm manure or commercial fertilizer, but even when these are used, the farmer should take advantage of the natural means so far as possible. If a soil is kept well supplied with organic matter, it usually has plenty of nitrogen because most of the nitrogen of the soil is in organic matter. The ultimate source of nitrogen is the air. Bacteria working on decaying vegetable matter are able to take nitrogen out of the soil air and so fix it for plant use. Bacteria working on roots of legumes also fix nitrogen. Adding organic matter in any way, keeping land in sod, and growing legumes are the chief ways of encouraging the fixation of nitrogen. A leguminous sod is usually better than a cultivated legume."

Summary. — There is a place for the judicious use of commercial fertilizers. However, their use should be studied more closely by our people. The three elements, nitrogen, phosphorus and potash, are the essential ingredients in fertilizers. Nitrogen is generally worth 18 cents per pound and each of the others $4\frac{1}{2}$ to 6 cents per pound. These elements are constantly being shipped to the cities, and of course should be returned to the soils if the fertility is to be maintained.

Nitrogen in fertilizers is high priced and may be put into the soil more cheaply by growing legumes. The element potassium is generally abundant in the soil. Phosphorus is the principal element we must consider in commercial fertilizers. Experiments have proved that best money returns have almost invariably been secured by the use of phosphorus fertilizers, to the exclusion of the other two elements.

When fertilizers are used, it is strongly recommended that farmers practice home mixing, if more than one element is needed for economic crop yields.

Commercial fertilizers are never all-sufficient. If they are used, all other good farm practices, such as the use of good seeds, rotation of crops, good culture, addition of manure, the growing of legume crops, and occasionally plowing under a legume crop —

all of these should be employed in order to insure good crops and the permanent fertility of our soil.

QUESTIONS

1. Name the three plant food elements found in commercial fertilizers. Name the three kinds of fertilizers.

2. Outside of the considerations of the manufacturers are there any good reasons to call fertilizers by such terms as "Corn Grower," "Special Potato Grower," or "Extraordinary Special Wheat Producer"?

3. Two hundred pounds of a 2–8–4 fertilizer adds how much soil fertility in comparison to that removed by a ton of dent corn? What is the cost of such a fertilizer?

4. What is the function of nitrogen, phosphorus, and potash in plant growth?

5. What is the best way for a farmer to determine the need of commercial fertilizer?

6. What are the points in favor of home mixing of fertilizer?

7. What is the cheapest source of supplying nitrogen to the soil?

8. What amounts of commercial fertilizers are applied to fields for the production of wheat and corn?

PROBLEMS

1. Secure from the Agricultural Chemist of your State Experiment Station their latest bulletin on the "Inspection of Commercial Fertilizers," and the current price of the elements in fertilizers; and accordingly figure the price of three fertilizers.

2. Secure small samples and the analysis of commercial fertilizers sold in your community.

REFERENCES

Whitson and Walster, Soils and Soil Fertility.
Vivian, First Principles of Soil Fertility.
Snyder, Soils and Fertilizers.
Voorhees, Fertilizers.

CHAPTER XXXII

MANAGEMENT OF DIFFERENT KINDS OF SOILS

Classification of agricultural soils. — Based upon texture and upon organic content there are at least four types of soil; namely, (1) Sandy soils; (2) Black loam soils; (3) Clay soils; and (4) Marsh soils. The approximate amount of different sizes of soil particles making up each soil is given in the chapters on Soil Texture, page 385. The management of each of these types of soil will be discussed in a general way.

Sandy soils. — Sandy soils vary in their composition, but in general may be thought of as having the following amounts of the different soil separates:

Sand, from 25 to 56 per cent.
Silt, from 10 to 30 per cent.
Clay, from 5 to 15 per cent.

Soils made up wholly of sand have little, if any, agricultural value, except in rare cases where the seasons are suitable and where they are located near a good market. In such cases they may be improved by the addition of manure and fertilizers so that they will produce some of the truck garden products.

Composition of the Upper 7 Inches of Sandy Soils

	Nitrogen Pounds	Phosphorus Pounds	Potassium Pounds
Sand	1675	620	39,750
Sandstone	1700	380	7,840
Light sandy upland	1100	250	2,100

It will be seen that sands are deficient in the essential elements of plant foods, for a well-balanced soil contains more of each of the plant foods than the above table shows.

There are four defects of sandy soils: (1) They are too porous, permitting percolation too readily; (2) They permit air circulation too freely; (3) They do not hold plant foods in the form of organic matter; (4) They lack in the mineral requirements of plant foods. Each of these disadvantages of sandy soils will be briefly discussed and remedies suggested.

1. *Sandy soils are porous.* They will not naturally hold sufficient water for plant growth. This can be overcome to a considerable extent: (1) By adding humus to the soil. Humus has at least $6\frac{1}{2}$ times the water holding capacity of sand. (2) By rolling and dragging the soil. This compacts the soil and thus excludes the free circulation of the air. (3) By the maintenance of a soil mulch. This may be done by cultivating the upper two inches with any implement that will keep it loose.

2. A sandy soil permits the air to circulate too freely through it. Although this makes a sandy soil an early soil, yet the air dries the soil unduly and has a tendency to oxidize or burn out the organic matter in the soil. Crops that mature in midsummer can scarcely be naturally matured by sandy soils because they burn up for lack of water. Sandy soils produce only early maturing or drought resisting crops.

3. Sandy soils do not hold the organic plant foods well. The water passes through these soils so rapidly that plant foods leach out. Following closely the suggestions of the above two paragraphs will help to prevent leaching. Winter cover crops, such as rye, wheat, etc., help in holding the plant foods intact. Some organic matter may be occasionally added by growing a green manure crop and plowing it under.

4. Sandy soils are deficient in the mineral ingredients of plant foods. Pure sands do not contain any of the essential plant foods; whatever plant foods are found in a sandy soil are there because of the presence of clay, silt and organic matter. A sandy soil

needs nitrogen and phosphorus and some potash. These may be added in the form of commercial fertilizers.

5. Truck crops, vegetables, strawberries and larger berries, potatoes, sweet potatoes, beans and legumes are adapted to sandy soils. Early maturing varieties may prove most profitable.

Black loam soils. — Black loam soils, which are classified as clay, silt, sandy and gravelly loams, contain a fairly well-balanced mixture of silt, clay and various grades of sands. The different classes of loam soils are due to the different proportions of silt, clay, sand, etc., found in them. The loam soils have a texture, a structure and water holding capacity which renders them fairly easily worked and at the same time they have a high percentage of the essential elements, both organic and mineral, to supply the needs of plants. They are the soils most commonly found in the farming areas of the United States.

Composition of the Upper 7 Inches of Some Loam Soils

	Total Nitrogen Pounds	Total Phosphorus Pounds	Total Potassium Pounds
Sandy loam	3070	850	26,700
Black clay loam	8900	1870	37,370
Yellow silt loam	1870	870	32,720
Fine sandy loam	2170	960	35,640
30 bushels of wheat removes	48	9.2	23.9
50 bushels of oats removes	50	7.8	37.4
65 bushels of corn removes	85	14.0	78.9
225 bushels of potatoes removes	67	10.6	64.4
2.4 tons red clover removes	102	10.9	69.2
4 tons of alfalfa removes	200	17.9	95.9

The average black loam soil is a well-balanced soil in its virgin state and if properly handled, by rotation of crops, by adding manures and by proper tillage, it may be kept in a high state of fertility for an indefinite time. Such a soil will respond to good farm practices even more readily than sandy or clay soils. The

black loam soils are adapted to the cereals, legumes and almost every crop grown, provided the seasons are favorable.

Clay soils. — Clay soils contain from 20 to 50 per cent of clay. A clay soil has the following textural composition:

1. Clay	50 per cent
2. Silt	30 per cent
3. Very fine sand	12 per cent
4. Fine sand	5 per cent
5. Medium sand	2 per cent
6. Coarse sand	1 per cent
7. Gravel	0 per cent

The chemical composition of different clay soils is as follows:

THE COMPOSITION OF SOME CLAY SOILS. UPPER $7\frac{1}{2}$ INCHES

	Total Nitrogen Pounds	Total Phosphorus Pounds	Total Potassium Pounds
Clay	3250	5600	12,000
Black clay loam	7380	2600	61,000
Drab clay	5800	1900	48,000

The black clay loam soils are richer, generally speaking, in all the mineral ingredients than sandy soils.

The small particles of a clay soil make it hard to cultivate. Clay soils have the following features, which are in some instances disadvantageous: (1) They are so tight that they do not drain easily; (2) They are often cold soils; (3) They puddle easily; (4) They are often deficient in phosphorus. How these deficiencies in clay soils may be improved will be discussed in the following paragraphs.

1. Clay soils do not drain easily. A two-inch rain will percolate away readily in a sandy soil; but, if a two-inch rain falls upon a closely textured clay soil in a short period, most of the water will drain off by surface drainage. It is for this reason that a clay soil erodes easily. Surface and underground drainage will aid in

protecting clay soils. These soils, especially sloping clay soils, should also be protected with grass. Clay soils hold the water well. This is true especially when a soil mulch is maintained.

2. Clay soils are known as cold soils. They retain the soil water so persistently that they do not warm up readily in the spring. Drainage, the addition of organic matter, and fall plowing will overcome this to some extent.

3. Clay soils puddle easily. They cannot be plowed when the least bit wet. A clay soil forms a solid crust after each rain. This shows a poor structure of the soil. This may be overcome by adding organic matter, by leaving stubble on the soil, by adding barnyard manure, or occasionally plowing under a green manure crop. The addition of lime will help to improve the structure of the soil. The growing of crops like alfalfa, with deep penetrating roots, will also help to make the soil more porous.

4. Clay soils are often deficient in phosphorus. They are usually rich in potassium, but lacking in phosphorus and sometimes in nitrogen and lime. The phosphorus may be supplied by the addition of floats, or other forms of commercial fertilizers. Nitrogen can be most easily supplied by the growing of leguminous crops. Peat is found in some localities, and it may be applied to clay soils to furnish nitrogen.

The grasses, such as blue-grass, redtop, corn, wheat, oats, barley and rye are especially adapted to clay soils. The shallow rooted grasses prefer a compact soil, one exposing a lot of soil surface to the roots and one holding a good deal of moisture. The looser clay soils will also produce legumes, especially soy beans and cowpeas.

Marsh soils. — Peat, marsh and muck soils are all the result of deposits of plant remains. A peat soil is made up of organic matter, in which the plants have not undergone complete decomposition. In muck soils the organic matter shows greater decomposition. And in marsh soils the organic matter is thoroughly decayed.

The composition of a few of these soils follows:

AMOUNT OF TOTAL PLANT FOODS IN SURFACE 7 INCHES

	NITROGEN POUNDS	PHOSPHORUS POUNDS	POTASSIUM POUNDS
Peat	8,000	340	1100
Deep peat	21,000	2800	2560
Muck soils	18,000	600	

These soils contain an abundance of nitrogen, but are usually deficient in phosphorus and potassium.

Marsh, muck and peat soils are of organic formation, and are therefore very black in color. These soils have the following deficiencies: (1) They often lack drainage; (2) They are generally acid; (3) They lack phosphorus; and (4) They sometimes lack lime.

1. Marsh soils often lack drainage. Being formed in swamps, lakes and lowlands they are wet soils. More than that, the soil particles of these soils are very small, and, of course, this prevents the free passage of water through them. Surface and underground drainage often makes these soils very productive.

2. Muck, marsh and peat soils are often acid. The acidity of these soils is caused by the formation of humic acids during the processes of decay. Since these soils are often deficient in lime, ground limestone rock may be added to good advantage. This corrects the acidity and overcomes the deficiency.

3. Muck, marsh and peat soils are usually deficient in phosphorus. Often only 200 to 300 pounds of phosphorus per acre are found in the tillable surface soil, and this is insufficient to produce average crops. For it will be remembered that only a small amount of the plant food in a soil is available to plants. Hopkins states, "We can assume for a rough estimation that the equivalent of two per cent of the nitrogen, one per cent of the phosphorus, and one-fourth of one per cent of the total potassium contained in the surface soil can be made available during one season by practical methods of farming."

The fact of it is that the roots of plants come in contact with but a small fractional part of the soil, and it will be evident, if Hopkins' statement is true, that less than five pounds of the phosphorus would be made available for plants in one season. It is for this reason that phosphorus fertilizers must be added to muck, marsh, or peat soils to get economic returns.

Potassium likewise is often deficient in these soils, as is shown by the following illustration.

4. The hay crops are best suited to marsh lands, but when these soils are well drained they become the most prolific soils in the production of almost all crops.

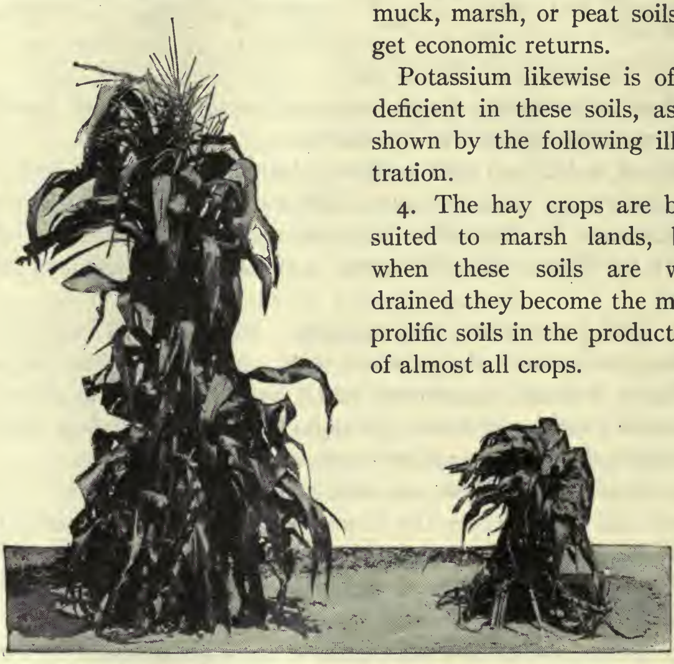

FIG. 172. — The effect of $3.50 worth of potash per acre on a marsh soil. It would seem that a potash fertilizer should receive some consideration when an application of 150 pounds of potassium chloride will produce 15 tons of ensilage corn where only 3 tons would grow otherwise. WISCONSIN STATION.

Summary. — Soils of various types — sandy, clay, black loam and marsh soils — vary in texture, composition and topography, and therefore deserve careful study. Crops adapted to each soil will bring best returns. The needs of one will not suffice for another. Although the suggestions given in this chapter and in previous chapters are helpful, they are still inadequate, for at

best they can only be general in their application. Your state experiment station, your county farm agent, or the soil survey map of your county will give additional data. (Not all counties have such a survey. Only about 1600 counties have been surveyed, 1918.) It is to be hoped that our soils will not be undermined, but that such practices will prevail as will render them permanently productive, for as Hopkins states: " It is the first business of every farmer to reduce the fertility of the soil by removing the largest crops of which the land is capable; but ultimate failure results for the landowner unless provision is made for restoring and maintaining productiveness. Every landowner should adopt for his land a system under which the land becomes better rather than poorer."

QUESTIONS

1. State in percentages the soil separates found in four types of soils.
2. In what elements are sandy soils deficient? How may these be supplied?
3. What crops are adapted to sandy soils?
4. What are the chief deficiencies of sandy soils? How may each be corrected?
5. What is the textural composition of a black loam?
6. What are the good features of a black loam soil?
7. What crops do best upon black loam soils?
8. What is the textural composition of clay soils?
9. Clay soils are often deficient in what plant food elements?
10. Clay soils have what further deficiencies?
11. What crops thrive best upon clay soils?
12. What kinds of soils are marsh, muck and peat soils?
13. What plant foods do marsh, muck and peat soils lack?
14. What is your recommendation regarding the management of peat soils?

PROBLEMS

1. Write a five hundred word essay on "Soils and How to Maintain Their Fertility."
2. Write a five hundred word essay on "How to Double the Crop Yield upon Some Specific Piece of Land."

REFERENCES

Whitson and Walster, Soils and Soil Fertility.
Hopkins, Soil Fertility and Permanent Agriculture.

SECTION IV. HORTICULTURE

CHAPTER XXXIII

VEGETABLE GARDENING

Importance of the vegetable garden. — Exclusive of the Irish and sweet potato crops, the vegetable garden products of the United States for 1909 were valued at $216,257,068.[1] The value of the Irish potato crop for the same year was $166,423,000, and of the sweet potato $35,429,000. Vegetable gardening has increased according to the best estimates about 200 per cent. This is due to a demand for more food.

The home garden. — This chapter deals with the home garden, — the small garden, whether on the farm or the city lot, intended for family use. The special problems of commercial gardening do not fall within the scope of this book.

The importance and advantages of the small kitchen garden have not always been fully appreciated. Some of its advantages are as follows:

1. The garden furnishes diversion from the daily routine of work. This outdoor work gives exercise, recreation and health to the gardener. It helps to bring parts of the body and mind into activity that otherwise would become dwarfed. Garden work supports and builds up the tissues and organs of the body.

2. With little preparation vegetables furnish excellent food and a variety of good food throughout the year. The daily fare is quite different from what it was 50 or 100 years ago. Bread and meats made the major portion of the diet at that time; but to-day green, crisp, succulent vegetables supplement the human

[1] Census Report.

diet. Vegetables add palatability to the menu. Not only are they used more extensively for their relish and seasoning qualities, but for their food value. The following table gives the composition of a few of the leading garden products.

AVERAGE COMPOSITION OF VEGETABLES [1]

	WATER	PROTEIN	FAT	CARBO-HYDRATES	ASH	CALORIES [2] PER POUND
Milk (for comparison)	87.0	3.3	4.0	5.0	0.7	310
Potatoes	82.2	1.8	0.1	14.7	0.8	295
Sweet potatoes	55.2	1.4	0.6	21.9	0.9	440
Tomatoes	94.3	0.9	0.4	3.9	0.5	100
Beans (string)	83.0	2.1	0.3	6.9	0.7	170
Cabbage	77.1	1.4	0.2	4.8	0.9	115
Peas (green shelled)	74.6	7.0	0.5	16.9	1.0	440
Green roasting ears	75.4	3.1	1.1	19.7	0.7	440
Beets	70.0	1.3	0.1	7.7	0.9	160
Turnips	62.7	0.9	0.1	5.7	0.6	120
Onions	78.9	1.4	0.3	8.9	0.5	190

It may be stated in general terms that vegetables contain about 75 to 90 per cent water; 5 to 15 per cent carbohydrates; protein, 1 to 2 per cent; ash, 0.7 to 1.0 per cent; and a small amount of fats.

That the mineral elements in vegetables are extraordinarily healthful, no one questions. Their liberal use in the dietary will result in better health and longer life. Vegetables add bulk to the food, vary the diet and are most satisfactory as a summer food because they are not as high in calorific value as the more solid foods. The calorific or fuel value of vegetables ranges from about 100 to 400 calories per pound.

3. The vegetable garden yields ten to fifteen times as much food on a given amount of ground as does the same soil tilled in

[1] Farmers Bulletin No. 142, Principles of Nutrition and Nutritive Value of Food.

[2] The calorie is the unit of heat, and is the amount of heat required to raise the temperature of 1 kilogram (2.2 lb.) of water 1° C., or one pound of water nearly 4° Fahr.

farm crops. And if the most intense methods of planting and culture are practiced the comparative yield is probably greater.

4. The vegetable garden lowers the high cost of living. This is an important item when other food products, such as flour, beans and meats, cost 8, 15 and 30 cents per pound respectively. Vegetables lower the cost of living but enhance living itself.

Saving space in the garden. — Space and time are saved by the use of "companion crops," "succession crops" and "marker crops." When two crops are growing on the same soil at the same time they are known as companion crops. Lettuce and beets may be growing side by side. Pole beans and corn are grown together. These are companion crops. A "succession crop" follows another crop. Corn, pumpkins, tomatoes are often grown in potatoes. Early lettuce, radishes, and onions are followed by corn, tomatoes, and beans. These are examples of succession crops. A "marker crop" is used to show the location of seeds planted which germinate slowly. Thus, radish seeds and other quick germinating seeds may be planted in the same row with beets, parsnip, and onion seeds to mark the spot where these slowly germinating seeds were planted. Gardening may be intensified by the use of the three kinds of crops mentioned.

Some garden suggestions.

1. Do not make small beds or patches in the garden.
2. Never make paths in the garden, for they act as the best conductors for the escape of soil water.
3. Do not plant tall growing plants by small growing ones.
4. Never till the soil when it is too wet.
5. Make the rows as long as possible.
6. Plant seeds in rows just far enough apart so that they do best and can be cultivated most easily, either by hand or with a horse cultivator.
7. Place the permanent plants near the edge of the garden.
8. Cultivate freely after each rain, when the soil is in good condition.

The following suggestive plan may be followed.

EAST.

Asparagus.		Rhubarb.	Artichoke.	6 ft.
Parsnip.	Salsify.	Cucumbers, followed by Fall Spinach.		6 ft.
Peas				4 ft.
Early Potatoes or Peas, followed by Celery.				4 ft.
Early Cabbage and Cauliflower.				3 ft.
Beets.		Turnips.		3 ft.
Lettuce, early and late.	Winter Radish.	Endive.	Parsley.	2½ ft.
Onions, with early Radish sown in row.				2½ ft.
Bush Beans.				2½ ft.
Late Cabbage.				4 ft.
Early Corn and Summer Squash.				4 ft.
Late Corn.				4 ft.
Tomatoes and Pole Beans.				4 ft.
Musk and Watermelon.				6 ft.
Winter Squash.				8 ft.
				8 ft.

WEST.

FIG. 173. — A well-planned garden.

A garden for the entire year. — Just as the work of the average man extends over the entire year, so should the vegetable garden be a 365-day garden. Some emphasis should be laid upon the quick maturing vegetables, such as lettuce, radish, mustard, spinach, onion, string peas, and beans, but an especial emphasis should be placed upon the production of more permanent products, such as potatoes, sweet potatoes, navy beans, peas, corn, tomatoes, cabbage, pickles, beets, and pop corn. Drying, canning, pickling, preserving, and storing should be employed in making the garden a 365-day garden. It is to be hoped that the garden is managed so that at least two or three vegetables may be found on the table daily.

Factors in vegetable production. — There are several factors essential to the best results in producing vegetables. Some of these will be discussed.

1. *The soil* is one of the most important considerations in vegetable production. A black loam soil, with a small amount of sand,

and a good supply of organic matter is one of the greatest assets to successful gardening. Preparation of the soil by manuring and plowing the preceding fall is also very helpful in getting an early start and putting the soil in the best condition so that it will liberate the maximum amount of plant foods. The growing of beans and peas will help very much in maintaining the best physical and chemical condition of the soil.

2. *Hotbeds* may be used to grow small vegetables to maturity, but their main use is to give plants an early start. For illustration, it requires 100 to 140 days for tomatoes to mature. The hotbed really assists in securing tomatoes 20 to 40 days earlier than if they were started in soils outside of the hotbed. Sweet potatoes and cabbage are likewise ready for table use much earlier if they are started in a hotbed.

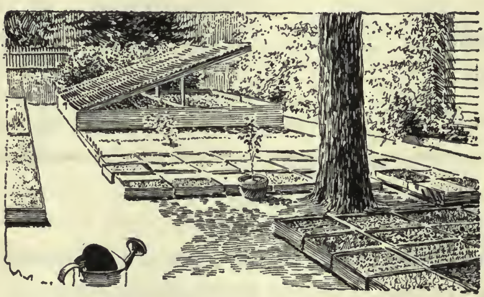

FIG. 174. — A hotbed and cold-frames used in prolonging the growing season for plants.

A hotbed is made by digging a pit about 18 inches deep, filling it with about 14 inches of good fresh horse manure, and covering this with about 6 inches of soil.

Cold frames are made like hotbeds except that they are built on the top of the soil and no manure is used. Cold frames are used to harden off plants.

3. *Transplanting.* — Transplanting plants when conditions are right and when the plants are of the correct size to transplant is important in successful gardening. There must not be a lack of moisture during or shortly after plants are transplanted. Water plants two or three hours before transplanting, transplant rapidly and keep the soil moist about the roots. Maintain a mulch about the plant, and water occasionally until the plant is well started.

Stocky plants of good size and with a good root system are easier to transplant successfully. A tomato plant with only 4 or 5 small leaves is too small to be transplanted. Such a plant has a small root system and ordinarily grows with difficulty, but if it has from 8 to 10 good sized leaves, the roots are larger and more numerous, and the plant will grow easily. The lower leaves should be pinched off and the plant should be set deep in the soil. Three important things to remember in transplanting are: (1) Transplant only those plants that are of good size; (2) Protect

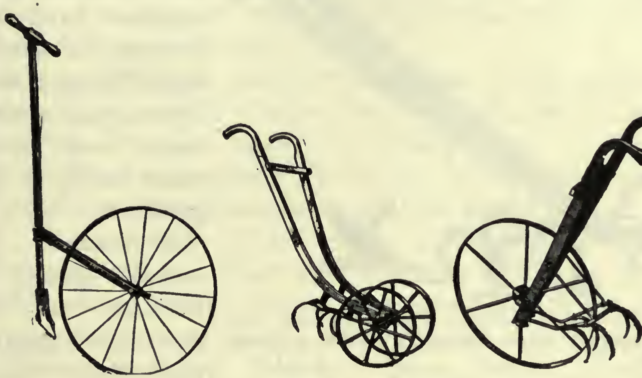

FIG. 175. — Some convenient garden tools.

the plant by giving it plenty of water to drink, and (3) Firm the soil tightly about the roots.

4. *Controlling the water supply.* — In the early spring there may be too much water in the garden soil, then it is a question of ridding the soil of surplus water. More generally it is a question of conserving the soil moisture. To this end keep the soil in good tilth and maintain a soil mulch by frequent cultivation and by cultivating after each rain as soon as the soil is in the right condition to work well. Soil water is often the most important factor in vegetable production, and how to conserve it is a vital factor in gardening.

In some cases where only a few cucumber or tomato plants are grown the soil may be mulched with cut grass, weeds, or straw.

This will protect the soil from the hot sun and winds, and thus conserve the moisture. Plants, tided over the dry spell, will often yield bountifully after rains.

5. *Cultivation of the garden.* — Where tools drawn by horses can be used in gardening, the cost of production is greatly reduced; but where this cannot be done, the best hand implement should be employed. The previous cut shows a fine type of garden tool.

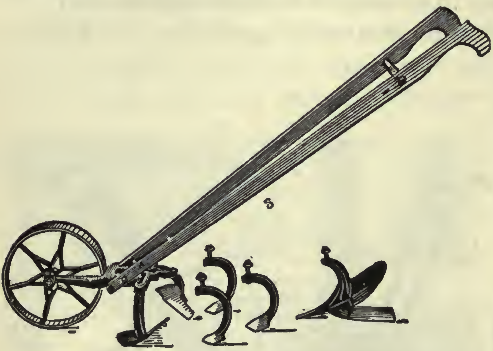

FIG. 176. — A single-wheel type of hand cultivator. Such an implement reduces considerably the labor of stirring the soil.

The single wheel hand cultivator is an excellent hand implement for garden work. It has several types of plow attachments and saves much hoeing in the garden.

6. *Fertilizers for vegetable gardens.* — Fertilizers are important in vegetable production. Stable manure is the best garden fertilizer. It furnishes the necessary plant foods; helps to warm up the soil in springtime; mellows and loosens the soil; causes the soil to work easier; and enables the soil to store more reserve water. Horse, poultry, or hog manure is especially good for garden use.

Green manure crops, such as peas, beans and rye, are often turned under. These improve the soil in its physical and chemical qualities. Although legumes add more nitrogen to the soil, rye furnishes an excellent cover crop for winter, and may supply a green field for the fowls which are often kept upon the town lot.

Commercial fertilizers are often used to restore and build up the fertility of garden soils. As much as 1000 to 1500 pounds per acre is often applied, or 10 to 15 pounds for every 20 square feet. Commercial fertilizers are purchased for three elements: nitrogen,

phosphorus, and potash. Nitrogen is conducive to vigorous leaf growth and is used in the production of lettuce, cabbage and chard. Phosphorus and potash aid in the production of seeds, fruit and roots; hence, are used in tomato, pea, bean and potato production.

Barnyard manure and green manure crops are best applied in the autumn; commercial fertilizers, when the seeds or plants are planted.

7. *Combating insects of the garden.* — Insects from the standpoint of control are discussed in the chapter entitled "Control of Insects." The common insect enemies of the garden might be reported upon at this point.

Factors influencing quality of vegetables. — The main factors influencing the quality of vegetables are: (1) Rapidity of growth; (2) Freshness when served; (3) Temperature; (4) Maturity; and (5) Method of serving. These five points affecting quality of vegetables will be discussed in the order mentioned.

1. *Rapid growth.* — Rapid growth is the prime essential in putting quality into vegetables. Rapid growth gives crispness, tenderness and flavor; whereas slow growth causes the plant to become tough, hard, woody, and in many instances produces an undesirable flavor. Radishes, turnips, lettuce, cabbage, cucumbers should be grown in as short a time as possible, in order to secure the quality most desirable in them. High quality in vegetables goes with rapid growth. And for rapid growth plenty of available plant food and a proper supply of moisture are fundamental.

2. *Freshness when served.* — Some vegetables wilt quickly when they are gathered, and lose their crispness. This is especially true of lettuce, peas and corn. These vegetables retain their best flavor and quality when served within a short time, an hour or two, after they are gathered. One of the greatest disadvantages of not having a vegetable garden comes from the fact that it is almost impossible to get vegetables that are fresh.

3. *Effect of temperature.* — Every vegetable prefers a definite temperature, and the best growth cannot be secured unless the

temperature is suited to the particular plant. Quality often is a direct result of the proper temperature. Vegetables may be classified as follows, according to season or temperature in which they thrive best.

1. *Cool Season Plants:*

Lettuce	Peas	Onions
Mustard	Early cabbage	Potatoes
Spinach	Early celery	Beets
Radishes		

2. *Warm Season Plants:*

Beans	Muskmelons	Sweet potatoes
Corn	Tomatoes	Late cabbage
Pop corn	Cucumbers	Watermelons
Egg plant		

3. *Late Summer and Autumn Plants:*

Beans	Navy beans	Turnips
Late cabbage	Corn	

The best quality cannot be secured in some vegetables, such as lettuce, radishes, peas and potatoes, in hot weather; nor can others, such as beans, tomatoes and melons, be grown in cool weather.

4. *Relation of maturity to quality.* — There is a certain stage of maturity of crops when they have the highest quality. When allowed to grow too long, peas and corn get tough and hard. Watermelons, muskmelons, corn and all other vegetables must be used at the proper stage of maturity if their quality is to be at its best.

5. *Method of serving.* — Wholesomeness, attractiveness and uniformity add quality to vegetables. Lack of uniformity, usually represents varying stages of maturity and hence a lack of quality. The following cut shows the difference of attractiveness because of lack of uniformity.

Carrots, peas, turnips, cabbage and other vegetables are not relished by some people because they have never eaten them when they were well prepared. When vegetables are properly prepared, they are as palatable and proportionately as nutritious as any other foods.

Rapidity of growth, moisture, plant foods, freshness when served, proper temperature during growth, harvesting at the proper stage of maturity and the method of serving are some of the factors influencing the quality and wholesomeness of vegetables.

Culture of Vegetables. — While we have discussed some of the factors that influence the growth and quality of vegetables in

A fine attractive uniform bunch of radishes. A poorly graded bunch of radishes.

FIG. 177.

general, there are many important points that can be brought out only in relation to specific vegetables. We cannot here deal with the culture of all of the vegetables of the garden, but will consider the more common ones.

1. *Lettuce.* — Lettuce is the most widely grown salad plant in America. It thrives in every section of the country and with the aid of glass is grown in many sections the entire year. Lettuce

responds to a fertile, black loam soil, and to cool and moist conditions. It is an early season crop and cannot be well grown in midsummer unless it is shaded.

Rapid growth gives lettuce the crispness so essential to quality. Frequent shallow cultivations should be given lettuce, in order to insure the conservation of moisture.

2. *Radishes.* — Although adapted to a wide range of climatic conditions, radishes do best in early spring and fall when the temperature is moderately warm. If they are to have the best flavor and the proper crispness, they must be grown quickly. A slow growth causes them to have an unpleasant, acrid flavor and a tough, fibrous texture.

Culture of radishes. — When radishes are grown alone, they are sown in rows 12 to 18 inches apart, one-half to one inch deep. The soil should be what is called a "quick soil," composed of sand, clay and humus. A "quick soil" can be tilled soon after a rain, because it is porous, permitting the rapid escape of free water, and because the black color, caused by humus, absorbs the sun rays and warms it quickly.

Radishes are often grown as one of a "succession crop," between two rows of lettuce. On each side of these three rows is grown a row of potatoes, cabbage, peas, beans, or sweet corn. A continuous supply of radishes may be had by sowing seeds at successive intervals of about ten days. If radishes are to be sold on the market, they should be tied in bundles of from six to twelve radishes. The tops are left on, because they protect the radishes to some extent.

3. *Garden peas.* — Peas are planted early in a deep, loose, friable, moderately warm soil. They are planted in rows from 12 to 15 inches apart and about 2 inches apart in the row. According to time of maturity there are a number of varieties of peas. If peas are desired throughout the summer different varieties should be planted at intervals of from 2 to 3 weeks during the season. Peas have hardly an equal as a food. They are rich in all the food ingredients, palatable, and easily grown. There

is no reason why every home in the United States should not have some peas of its own raising every year.

4. *Beans.* — Beans are grown like peas, but prefer warmer conditions. They thrive best in midsummer. String beans must be grown rapidly if crispness, quality, and flavor are to be at their best. Beans of varying kinds can be grown throughout the summer. They should be planted at successive intervals of about 2 or 3 weeks. A fertile soil is desirable for the production of beans.

5. *Navy beans.* — Navy beans grow under a wide range of conditions. There were 15,814,000 bushels (60 lb. to the bushel) grown in 1917. In 1918 the yield was about 19,000,000 bushels according to the crop reporter. In the immediate preceding years the yields were about half as large. Navy beans are an excellent food and deserve to be grown to a greater extent. Their food value follows:

FOOD VALUE OF NAVY BEANS, ETC.

	WATER	PROTEIN	FAT	CARBOHYDRATES	ASH	FOOD VALUE OF ONE POUND
						(Calories)
Navy beans	12.6	23.1	2.0	59.2	3.1	1615
Tomatoes	95.3	0.8	0.4	3.3	0.3	80
Apples	83.2	0.2	0.4	15.9	0.5	315
Corn meal	15.0	9.2	3.8	70.6	1.4	1645
Wheat flour	13.1	11.7	1.8	71.6	1.8	1635

From the above table it may be seen that navy beans are higher in protein content than any other food named. It is this that gives them additional value as a food. Navy beans are fairly high in producing heat and keeping the body warm, and for that reason they are a good food.

Navy beans are sown late so that the entire crop matures just before frost. For Missouri latitudes the planting date is about June 15–25. From twelve to twenty bushels per acre may be expected.

6. *Garden beets.* — Garden beets, which are a close kin to stock beets, mangel wurzels, are sown at the same time that radishes and lettuce are sown. A rich, rather loose soil is best adapted to beets. Close, tight, heavy soils do not produce beets well. Beets germinate slowly and it is well to plant a marker crop such as radishes with them. The culture of beets is like that of radishes or lettuce. Beets have about 150 per cent germination because each seed pod contains two seeds. This often causes them to be too thick. More beets should be grown, for they are prolific, and furnish an excellent food. If too many are grown for summer use they may be canned and stored for winter use.

It is also hoped that more sugar beets will be raised in the United States. Greater production of sugar beets has often been strongly urged by the government.

7. *Cabbage.* — Cabbage is a favorite garden vegetable throughout the United States, and in some sections it is grown extensively as a commercial crop. The tonnage produced per acre is large and the price generally low, but the sale of cabbage is assured because of its wide use. Cabbage requires a great deal of moisture for its growth, and for this reason may be planted in a soil that contains more than an average amount of moisture. There is an old saying that "cabbage should be hoed every day." This is almost true, for frequent cultivation maintains a soil mulch which conserves the soil moisture.

Cabbage requires an abundance of plant foods rich in potash and phosphorus. Stable manure may be applied, but, in addition, either acid phosphate at the rate of 750 pounds per acre, or muriate of potash at the rate of 500 pounds per acre, will help production. A fertilizer composed of nitrogen 2 per cent, phosphorus 6 to 8 per cent and potash 8 to 10 per cent is usually satisfactory. About 1200 to 1800 pounds per acre should be applied.

Varieties. — Copenhagen Market, Succession, Early Jersey Wakefield and Henderson's Early Summer are early varieties; the Flat Dutch, Stone Mason and Autumn King are later maturing varieties. Each of these varieties has been developed with flat,

conical, or spherical heads. Different markets demand different shaped heads. Catering to the demands of the market is a part of good gardening.

8. *Cucumbers.* — Cucumbers demand a fertile soil, and must have a lot of moisture for their growth. It is for these reasons that we plant them in low places, and continue to stir the soil so that a maximum amount of soil water may be maintained. Cucumbers are planted in rows from 6 to 7 feet apart, and about one foot apart in the row. The vines are kept in the row as much as possible, for this facilitates cultivation and gathering. Cucumbers are used in the fresh state and as pickles. The fact that they are used when still immature makes them adaptable to growth much farther north. Cucumbers are grown for their seasoning qualities. They have 80 calories per pound. The enemies of cucumbers are discussed in the chapter entitled "Control of Insects."

9. *Tomatoes.* — Tomatoes require from 100 to 140 days for maturity and therefore must be started early in a hotbed in order to get early tomatoes. Tomatoes prefer warm days and will not grow well in a cool soil. There is no use transplanting them until the soil is warm. They are set from three to four feet apart in the permanent growing place and constant cultivation is needed in order to get the best results.

There are many varieties of tomatoes. For early use the Earliana, Bonnie Best, Early Jewell and Stone are good. For late use plant Ponderosa, Acme, Matchless and Trophy. Some of the later varieties should be kept trimmed and staked.

Leaf spot is one of the worst enemies of the tomato. It is discussed elsewhere.

10. *Sweet potatoes.* — Sweet potatoes belong to the morning glory family of plants, and like a rather hot, medium dry, sandy, rich soil. Sweet potatoes are propagated by placing the tubers in hotbeds, and covering with about five inches of soil. The potatoes are bedded about four to five weeks before the plants or slips are wanted. The usual condition of the hotbed is maintained in starting the slips. When the slips are six to seven inches

tall, they are transplanted into the permanent rows. The permanent rows are usually ridged, as this gives additional chances for drainage and warmth, although some of the best authorities recommend level culture. Sweet potato plants are set about twelve to sixteen inches apart in the row, and the rows are from 28 to 34 inches apart. Such tools are used as will maintain the ridge on which the plants are set. The sweet potato is an excellent human food, containing about as much starch as the Irish potato, and its muscle building elements surpass those of the Irish potato. Sweet potatoes are adapted to the South, while the home of the Irish potato is in cooler regions.

11. *Corn.* — Every garden should grow some roasting ears of sweet and dent corn types, and a little pop corn. Roasting ears should be on the table two or three hours after gathering; and it is for this reason that every gardener should grow some corn, as it is impossible to get the desirable freshness in store bought corns. Such varieties and types of corn should be planted as will provide roasting ears for several months. Corn, dried or canned, helps in making the garden a 365-day garden.

If corn is started early, vining field beans may be planted by the corn stalks, and the stalks used as bean poles. Such a practice does not reduce the corn yield, and usually gives a fine crop of beans.

Summary. — Every home in the United States should have a vegetable garden, for it furnishes excellent food, yields from ten to fifteen times as much food as an equal area in farm crops, and reduces the cost of living. Time and space in the garden may be saved by the use of companion crops, succession crops, and marker crops. The garden vegetables should be so varied that the garden becomes a 365-day garden. Some factors essential in making the garden successful are soil, water supply, transplanting, cultivation, use of the hotbed, use of fertilizers and combating insects.

The quality of vegetables is influenced by rapid growth, freshness of vegetables when served, proper growing temperature, use at the correct stage of maturity and the method of serving.

QUESTIONS

1. What are the most common vegetables grown in your locality?
2. Compare the food value of potatoes, milk and beans.
3. Discuss canning and drying of vegetables, in the light of making the garden a 365-day garden.
4. Name and discuss the factors essential in making the garden a success.
5. Find the selling price of a dozen vegetables as they are usually sold at the grocers.
6. Estimate the money value of your home garden of last year or this year or both.
7. Draw the plan of a garden.

PROBLEMS

1. Compare the money value of the vegetable garden with five farm products.
2. Report on the origin, history, improvement of the tomato.
3. Discuss the growing of celery, rhubarb and asparagus.

REFERENCES

Lloyd, Productive Vegetable Growing.
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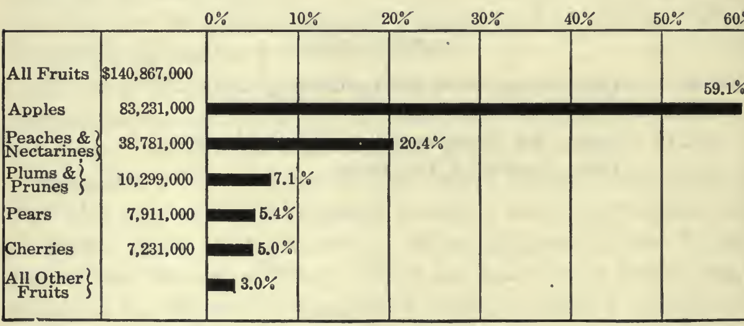
Gehrs, Productive Agriculture.

CHAPTER XXXIV

FRUIT PRODUCTION

Present conditions. — Fruit production on many farms and in town does not occupy the place it should. The reasons are the lack of space, the time required for the tree fruits to bear, and the lack of hardiness and longevity of the trees, and the tenant farmer. It may be well urged that practically every home builder grow some fruits.

The comparative value of the various fruits for 1909 is given in the following data[1]:



The value and per cent of fruits grown in the United States.

The distribution, production and money value of all fruits and nuts in the United States for 1909 are given in the following map. It may be noticed from the map that the states leading in fruit and nut production are California, New York, Michigan, Pennsylvania, Ohio, Missouri, Florida, Iowa and Illinois. Each state produces the fruits adapted to that section.

[1] Census Report

Readers of this chapter will ask the question, What is the outlook for an increased production of fruit? Since the population is increasing and the use of fruit is also increasing, it may be safely stated that the outlook is good. Good fruit is going to be at a

FIG. 178. — Map showing distribution of fruits produced in the United States.

premium for years to come. And the man with only a town lot may rest assured that every bushel of fruit he produces will save him money.

Advantages of fruit production. — It is the business of every grower of fruit to utilize all the points essential for best returns. He should know the adaptability of different fruits to soils of different types, the enemies of specific crops, and all the advantages and disadvantages of the production of a specific fruit.

The first advantage of fruit production is that fruits provide fine foods. Where can foods be found that are cheaper and more palatable, nutritious and healthful than fruits, especially when the fruits are grown at home? The composition and the calorific value of some fruits follow:

PERCENTAGE COMPOSITION OF FRESH FRUITS (AS PURCHASED)

	Water	Protein	Carbohydrates	Fats	Ash	Calorific Value per Pound
Milk, for comparison	87	3.3	4.9	4.3	0.7	310
Apples	83.2	0.8	14.2	0.3	0.3	315
Peaches	73.3	0.5	7.7	0.1	0.3	153
Cherries	76.8	0.9	16.7	0.8	0.6	354
Grapes	58.0	1.0	14.4	1.2	0.4	328
Oranges	63.4	0.6	8.5	0.1	0.4	169
Bananas	48.9	0.8	14.3	0.4	0.6	290
Blackberries	86.3	1.3	10.9	1.0	0.5	262
Currants	85.0	1.5	12.8	0.0	0.7	259
Strawberries	85.0	0.9	7.0	0.6	0.6	168

(Data Compiled by Atwater and Bryant.)

A second advantage of fruits is that they are healthful and aid in keeping the body in good condition. The old saying, "One apple a day keeps the doctor away," is worthy of being remembered. For it is really true that fruits have a salutary effect upon the digestive organs and upon the entire system.

For the man upon the city lot, the production of a few fruits provides diversion from his regular work. It gives outdoor exercise and recreation, and gives him a chance to study the soil, and the adaptability, habits and enemies of specific fruits, and their culture.

Kinds of fruit growers. — There are two classes of people interested in fruit production; namely, those who grow fruits for commercial purposes, and those who grow fruits for family use. The former tend to specialize. They seek to adapt the variety to the soil and usually grow only two or three varieties. The varieties grown are those which the market prefers. On the other hand, the person who grows fruits for the home produces various kinds of fruits, and in some instances a number of varieties of the same kind. For instance the grower of a commercial orchard may grow only the Ben Davis, Jonathan, Ingram, and Grimes

Golden, while the person growing apples for the home will grow many varieties so that the entire season yields apples. The grower of fruits for commercial reasons seeks a market, and caters to the wants of the market; the grower of fruits for the home considers no wants but those of his family. This chapter is written to a greater extent from the standpoint of the production and use of fruits for the family. The grower of fruits for the family is limited in his selection of suitable soil, and of orchard site, and he cannot cater to market demands, — he must do the best with the conditions at his disposal. It is the purpose of this chapter to aid the grower of fruits for family use to make the most of the conditions under which he has to work.

Orchard products for the entire year. — The home fruit garden should be a 365-day garden. In order to secure fruits for the spring, summer and autumn, such kinds and varieties must be grown as will provide fruit constantly. Strawberries, gooseberries, blackberries, raspberries, cherries, apples, peaches, plums and grapes of different varieties maturing at different times should be grown. Pickling, storing, canning and drying are employed in order to extend the benefits of the garden into the winter.

Some factors aiding fruit production. 1. *Soil.* — Every kind of fruit prefers a certain kind of soil, and even different varieties of some of the fruits prefer soils of different types. It is important that fruits be placed upon the soil to which they are adapted, for the larger fruits are unlike an annual. They must remain upon the same place for a number of years.

The subsoil should be deep and porous for tree fruits. The soil and subsoil should be of such a texture and structure that the trees may have a deep-penetrating root system. A deep root system is better able to withstand winds and drought. And again, a porous soil permits aëration, a highly important factor in fruit growing. Soil fertility in the production of most fruits is not as important as the porosity and general adaptability of the soil. The adaptability of various fruits to specific kinds of soil will be discussed in connection with the more important fruits grown.

The soil should be well prepared before the orchard is set out. An excellent preparatory crop is the cowpea or the soy bean. The soil should be plowed deeply and be well worked down.

2. *Transplanting.* — One of the most important considerations in transplanting is the selection of strong, stocky plants, with a medium heavy stem, and an abundance of roots. It should be remembered that good roots can soon grow a large top, but that a large top will almost certainly die if its root system is small. If the soil is in good condition and if the transplanted plant is healthy and vigorous, it is almost sure to grow.

The following principles may be well observed in transplanting: (1) Set the plants out at the proper season; (2) Do not permit roots to air dry in removing the plant from its original place in the nursery to the place where it is to be planted; (3) Fill loose, friable soil closely about the roots, so that the plant is in contact with the soil; (4) After the roots are well covered, compact the soil tightly about the roots in order that the soil air is excluded to some extent, and water may be taken up by the plant; (5) In case of a dry season, water the plants; and (6) Keep the surface soil mulched with either dry grass or a soil mulch.

3. *Tillage.* — In olden times it was held by some that a sod provided the best condition for orchards, but this opinion has long been overthrown. Orchardists and fruit growers are well aware that cultivation of fruits yields as good returns as the cultivation of corn. First, the unplanted plot should be well prepared by deep plowing and putting it in proper tilth. Secondly, the young orchard should be tilled for the following reasons: (1) Cultivation causes more plant foods to become available. The plant foods are often not available to plants, but when the soil is stirred they become available. (2) Cultivation keeps down the weeds, which would otherwise appropriate much soil water which should be conserved for the use of the plants. (3) Cultivation improves the physical condition of the soil and a good physical condition of the soil is needed if the stores of plant foods are to be unlocked. (4) Cultivation helps to conserve soil moisture.

The soil mulch is just as effective in the orchard as in the garden or in the field.

The disk harrow, smoothing harrow, or cultivator may be used in the cultivation of the orchard. In fact in apple, peach, pear, cherry, or grape orchards such crops as potatoes, beets, cabbage, beans, cowpeas, and occasionally corn, may be planted. Cover crops, such as rye, vetch, cowpeas and clover, protect the soil and add organic matter; the legumes also add nitrogen to the soil. Cover crops are sown in July or August. Frequent surface cultivations are given again the following spring and summer.

4. *Moisture.* — A proper amount of moisture is an important factor in fruit production. A loose soil and subsoil are adapted to the production of some fruits because they permit the root system to go down and thus be removed from the surface soil, which fluctuates to a greater extent in its water content. A clay soil becomes saturated so quickly at the sur ace that it is not well adapted to fruit production, for much of the water falling upon it runs off. The first essential is to catch a maximum amount of soil moisture. It is for that reason that a loose soil is preferred. After the water has been caught it must be conserved. This can be done best with the soil mulch. The importance of the proper moisture supply for fruit production can hardly be overemphasized.

5. *Pruning.* — Pruning is such an important factor in fruit production that the amateur will profit by going to see the work of an experienced orchardist, and securing his advice. The following general suggestions may be put into operation. The three main reasons for pruning are: (1) To control the size and shape of the top; (2) To remove dead branches; (3) To stimulate and promote either vegetative growth or fruitfulness.

(1) Trees should be pruned to a pyramidal shape, or an open vase form. Forked trees are undesirable. The tree may be pruned when young so that the head of the tree is near the ground. This method has some important advantages. The trunk of the tree will be protected from the sun, and sun scald prevented.

Trees are not as easily wind broken. The work of gathering, spraying and pruning can be done more easily and cheaply.

(2) All dead branches should be removed. Water shoots and other limbs that tend to crowd the top should be pruned out in order that all the strength of the tree may go into the growth of the desirable limbs or fruit.

FIG. 179. — A shapely open-headed apple tree. Note how close the limbs are to the ground.

(3) To promote vegetative growth trees should be pruned in winter. But if they grow too vigorously, they should be pruned in summer. This checks vegetative growth and causes the additional plant food to form buds. These fruit buds are formed in June and July of the summer preceding the bearing season. If pruning is employed to stimulate fruit production, it should be done about the first of June.

A few other suggestions on pruning will be made in connection with the discussion on the leading fruits in succeeding paragraphs.

6. *Spraying.* — Spraying is the most important single operation in the production of fruit. The following two cuts illustrate a typical experience in the value of spraying.

Spraying has the following values.

(1) It is the final factor in fruit production which insures quality to the fruit. Without spraying no one can expect well-formed and well-developed fruit at the present time, for there are too many enemies.

(2) Spraying has a valuable influence upon the tree, for the foliage and wood are freed from enemies, and this gives the tree a chance to produce a vigorous growth. Old renovated orchards recuperate wonderfully when sprayed.

In spraying the following considerations are practical: Use the correct spray. Do not waste ammunition in spraying. Be sure to know what pest or pests you are combating and then drive to the mark with the spray or sprays that will do the work

FIG. 180. — Sprayed apples, — 84 per cent of the apples were clean and marketable; 16 per cent were wormy and unmarketable.

successfully. The codling moth requires a definite kind of spray, while apple rot and scab need different treatment.

Spray in time. It is easier to kill the first brood of the enemy than to wait until the second and third crops have also appeared. For the first brood is usually small, but several broods constitute

FIG. 181. — Unsprayed apples, — 17 per cent were clean and marketable; 83 per cent were wormy and unmarketable.

a vast host. Again, in the case of the codling moth, it is impossible to kill the worm after it has penetrated into the apple. Spray thoroughly. Every part of the tree and foliage should be sprayed.

Turn to the chapter on "Insect Control," where a spray calendar of plant enemies and their habits and control is given. For further reference turn to specific bulletins and books.

7. *Harvesting.* — After the fruit has been produced, if the orchard is to be a 365-day orchard, it is important that the fruit shall be gathered at the proper time and in the proper way. To permit fruits to become overripe, or to permit them to fall off the tree, is wasteful.

All fruit should be carefully hand picked and handled in such a manner that it is not bruised or peeled in any way. Fruits

FIG. 182. — The time to spray for the codling moth. The calyx still open. Three more sprays are needed. Too late to spray for the codling moth. The calyx closed. This is about the size of apple ready for the third spray.

should be picked with the stems to prevent tearing the flesh of the fruit. It is at this torn place that decay sets in, and that the fruit begins to dry. This is especially true of apples, pears, grapes, cherries and plums. Of course, this general rule is not as important if the fruit is to be used immediately. Hand picking is the only satisfactory method at the present time. At what stage of maturity are the different fruits to be picked? This cannot be definitely answered. Most fruits are best when mature. But when fruits are to be marketed at a distance they are usually

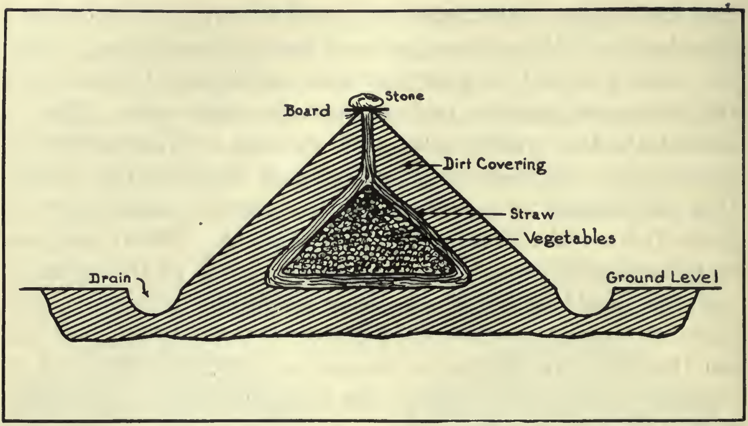
harvested earlier. Soft, quickly perishable fruits, such as cherries, strawberries and plums, are gathered before they are ripe. Pears are picked greener than any other fruit. Ripening of pears causes them to become granular, and some varieties begin to rot. Peaches present the best quality when well matured, and for immediate use should be left upon the trees as long as they will stay. When they are shipped to a distant market, they are picked early, in proportion to the time required in shipping. Blackberries are mature when they taste ripe, and are ready to fall off the bushes.

Fruits should be handled as little as possible in picking. All fruits with long stems should be picked by grasping the stem and not the fruit. In the case of grapes, the bunch should never be touched. The operator grasps the stem and snips it off with a pair of shears. Handling fruits bruises them, and also rubs off the bloom. This detracts from the fruit, and hence decreases its selling value.

8. *Storage.* — Fruits should be stored so that they will retain the best quality. The apple is the principal fruit referred to in this section. Apples stored in cellars usually become dry, shriveled, and tough. They lose their flavor and in comparison to apples properly stored, they taste flat.

The essential factors to be taken into consideration in storing apples are: (1) Proper temperature. A temperature of 40° to 50° Fahr. is a good storage temperature for small quantities of apples. The storehouses for storage on a larger scale should have a uniform temperature near 32° Fahr. (2) Proper moisture is a feature essential in the maintenance of quality. The humidity of the air varies greatly with different conditions, but it has been suggested by a good authority that an atmosphere with 80 per cent saturation provides the best moisture conditions for storage of apples. (3) *Fresh* air without rapid circulation is desirable in preventing disagreeable flavors.

For the storage of a small quantity of apples for family use, a pit dug in the ground is probably the most convenient, and the cheapest method.



Courtesy U. S. Department of Agriculture.

FIG. 183. — Cross section of a storage pit containing Irish potatoes. During severely cold weather the dirt covering may be supplemented by manure, straw, etc.

To construct such a pit, dig a hole in the ground about 12 inches deep, put in a layer of straw, put in apples, cover the apples with a layer of straw, cover pit with a substantial board roof which rests some 4 or 5 inches above the apples upon a solid frame, then cover the pit with sufficient soil to protect the apples from freezes.

A small ventilator made of four boards nailed together will permit proper air circulation. An open ditch drain should be provided to carry surplus water from the surroundings of the pit.

Only sound, well-formed apples of excellent quality should be stored. Before being stored for winter, they should be sorted. All inferior or blemished apples should be thrown back, and used as soon as possible. It is possibly best to wait several weeks after harvesting for the permanent storage of apples. During this time they may be stored by piling the apples and covering them with straw and canvas.

9. *Drying* and *canning* are important factors in the use and preservation of fruits, and for fuller treatment consult bulletins and books.

The common fruits. — It is important to know the importance and value of some of the more common fruits grown in the United States. It is necessary also to consider these common fruits separately because culture methods differ for different fruits.

1. *The apple.* — (Census data 1910). Apples in 1909 yielded 59.1 per cent of all fruits produced. The yield was 214,683,000 bushels, worth $140,000,000. This was a yield of about 2.14 bushels per person. The number of bushels of apples produced in 1918 was 197,360,000. The number of trees of bearing age in 1909 was 151,322,000 and the number not of bearing age was 65,791,000.

The ten leading states in number of apple trees of bearing age in 1909 were as follows:[1]

Leading Apple States

State	Number of Trees of Bearing Age	Bushels of Apples
Missouri	14,359,000	9,968,000
New York	11,284,000	25,409,000
Illinois	9,900,000	3,093,000
Ohio	8,500,000	4,663,000
Pennsylvania	8,000,000	11,048,000
Arkansas	7,650,000	2,296,000
Michigan	7,534,000	12,332,000
Virginia	7,000,000	6,103,000
Kansas	6,929,000	1,356,000
Iowa	5,847,000	6,746,000

Other states that ranked high in production were Kentucky, North Carolina, California, Maine, West Virginia, Tennessee. Each of these states produced over four million bushels of apples in 1909.

Apple soils. — Apples will grow on a great variety of soil, and for a family orchard it is impossible to describe the kind of soil best suited for apple production. However, for the best growth

[1] Census Report.

apples prefer a loose subsoil. And the texture of the soil is more important than its intrinsic fertility. The latter condition may be improved, but the former cannot be entirely overcome even by dynamiting. The subsoil for apples may even be gravelly or slightly stony. Plant foods must be provided.

Varieties for a home orchard. — The producer of apples for commercial purposes raises only a few market varieties. The family orchardist raises varieties of apples that will mature throughout the summer. The following varieties are named according to seasonal maturity.

Summer	Fall	Winter
Red June	Grimes Golden	Stark
Yellow Transparent	Huntsman Favorite	Gano
Red Astrachan	Jonathan	Wealthy
Early Harvest		Ingram
Maiden Blush		Delicious
Benoni		Ben Davis
		York Imperial
		Baldwin
		Stayman Winesap
		Winesap

The winter varieties should be planted in greater numbers. They mature late in the fall, and provide fruit for the winter months. Apples are planted from 25 to 35 feet apart.

Pruning. — In the first place practically every fruit tree should be pruned from the beginning, so that it has a shapely symmetrical top, with a rather short (20 to 24 inches) trunk.

Again, in pruning the apple it is very important to know that the fruit is borne on short stublike branches, known technically as "fruit spurs." Fruit spurs will remain short and stublike and will bear fruit for a number of years. But the long, rank water shoots may be cut out. Trees may be pruned any time of the year, but the time of pruning and the pruning given are determined by the purpose for which it is done.

Enemies of apples. — Besides those enemies discussed in the chapter on the "Control of Insects" we should acquaint ourselves with the habits of the apple borers. The apple borers are of two kinds, the round headed borer and the flat headed borer. The round headed borer bores under the bark near the surface of the ground. The flat headed borer works from 2 to 5 feet above the surface of the ground. These borers are killed in the same manner. Use a knife to find the openings made by the worm and then insert a wire into every opening made by them. This will destroy them if every portion of the opening is penetrated.

FIG. 184. — The limb to the left produces vegetative growth only. The one to the right has an abundance of fruit spurs. Note the difference in shape of the two limbs. In pruning the fruit spurs must be carefully protected.

2. *Peaches.* — The importance of the peach and nectarine crop in 1909[1] in yield was 35,470,000 bushels, or about $\frac{1}{3}$ bushel per person in the United States. In 1918 the yield of peaches was 40,185,000 bushels. The five leading states in production and the number of bushels produced in 1909 were the following:

California	9,267,000 bushels
Georgia	2,555,000 bushels
New York	1,736,000 bushels
Michigan	1,686,000 bushels
Kentucky	1,623,000 bushels

[1] Census Report 1910.

Soils for peaches. — Peaches prefer a porous, loose subsoil. A soil that is slightly sandy is best suited to peach production. Peaches will not thrive in a compact, wet soil. They are planted about twenty feet apart.

Varieties. — In the planting of any fruits it will be well for the grower to refer the question to his own state horticulturist for the varieties of different fruits that are suited to different conditions. However, the following list of peaches is given as suggestive, according to seasonal maturity.

Summer	Fall
Carmen	Heath
Champion	Beauty
Sneed	Iron Mountain
Elberta	Krummel October
Crosby	

Peaches do not bear fruit on fruit spurs. The fruit is borne on last year's shoots, and for that reason when the peach limbs are frozen or are not likely to bear, the limbs are cut back or the tree is "dehorned," as it is often called. An apple will bear fruit for years on the same fruit spurs, but peaches are always grown on last year's wood. Old timber in peaches therefore is of no value. It is for this reason that the old wood is cut back so severely.

For combating the enemies of the peach, refer to the chapter on the "Control of Insects."

3. *Pears.* — The number of bushels of pears produced in the United States in 1909 was 8,840,000, and the number of trees of bearing age was 15,171,000. New York state was the only state that produced over one million bushels in that year. In 1918 there were 10,342,000 bushels of pears produced in the United States.

Pears do well in a variety of soils. However, they do best in a deep clay loam. Soils adapted to apple production are also

well suited for the growing of pears. Pears are planted from 12 to 16 feet apart.

The Keiffer is probably the most common variety and is considered the standard variety. Some other varieties are Anjou, Bartlett, Seckel, Duchess, Favorite, and Garber. Pears mature at different seasons and should be planted so that they will mature over the longest season possible.

The worst enemy of the pear is the blight. It attacks leaves, flowers, fruit and stems. The parts affected turn black and die. The bacteria causing the disease live between the bark and the wood. Blight cannot be eradicated or even hindered by spraying. The only remedy known for the blight is to cut out all affected limbs, and burn them. The wounds should be painted with coal tar.

4. *Plums.* — There were 11,822,000 plum trees of bearing age in 1909, and they bore 4,125,000 bushels of fruit. Plums are quite well distributed throughout the United States. The distance for planting plums is about 20 feet. Plums prefer rather moist places on north slopes and along streams.

The plum varieties are as follows:

American Plum Varieties

Milton	Wild Goose
Robinson	Newman
Missouri Apricot	Wayland

Japanese Plum Varieties

Abundance	Burbank

European Plum Varieties

Green Gage	German Prune
Lombard	Damson

The plum curculio is the chief enemy of the plum. For its control see the chapter on the "Control of Insects."

5. *Cherries.* — Cherries grow best in a rather dry, porous, well-drained soil. Trees should be set from 15 to 20 feet apart. After

the third or fourth year there is little need for cultivation. If they are cultivated after this, the tillage should be very shallow, because the roots of cherries grow very near the surface of the soil. The best known varieties are:

Early Richmond	Wragg
Montmorency	English Morello
Lambert	Burbank

6. *Grapes.* — There should be grapes in every orchard. They furnish an excellent arbor, are sure bearers, and provide a good fruit. A well-drained but moist soil is best adapted to grape production.

Grapes are propagated by cuttings and layers. Layers or cuttings may be planted in the permanent place or orchard when one or two years old. The vines should be trained to grow on a three-wire trellis. They may be expected to bear when three or four years old.

Grapes must be pruned annually before the sap rises, about February or March, for the fruit is borne only on the current year's wood. The branches upon which the fruit was borne the preceding year are cut back so that 3 to 5 branches are left, with 3 to 8 buds on each branch. The number of twigs and buds left on the plant depends upon the vigor of the plant. The idea in pruning grapes is to secure a maximum amount of fruit.

Varieties of grapes. — The common standard varieties of grapes are the following:

Green Mountain, an early white grape.
Moore's Early, an early black grape.
Campbell's Early, an early black grape.
Moore's Diamond, a white grape.
Worden, a large black grape.
Concord, the old standard black grape.
Wyoming Red, a small red grape.
Niagara, best known white grape.

7. *Small berries.* — *Strawberries* prefer a black loam soil that is fairly rich and moist. Strawberries are set out in early spring

or in August or September. If set in the spring they are cultivated throughout the summer. The rows are planted about 36 inches apart, and the plants are set 16 to 20 inches apart in the row. When the runners put out it is well to keep them trained along the row for convenience in cultivation and picking. The strawberry bed should be mulched, with wheat straw preferably, for the winter.

Some of the varieties of strawberries are Gandy, Warfield, Senator Dunlap, Klondike and Aroma. The ever-bearing strawberry, which is gaining favor in some localities, bears some fruit throughout the season. The best known ever-bearing varieties are the Superb and Progressive.

Some varieties of strawberries bear only incomplete flowers, that is, pistillate flowers; and hence will not bear fruit unless some variety is planted alongside of them bearing stamens, so that the flowers are fertilized. Practically every city lot as well as every home garden should grow some strawberries, for they do not require much room and are prolific bearers, and their fruit is very palatable and fairly nutritious.

Blackberries, raspberries, gooseberries and *currants* may be grown under general good garden conditions, and since they occupy only a small amount of space, they should be grown more extensively than they are at the present time. They are grown most frequently as border plants, or in the corner of the garden. Clean cultivation in summer and a straw mulch in the winter are conducive to the highest thrift of the plants.

Summary. — Fruit growing has not reached the importance it should reach in the United States. The outlook is better, for the number of trees coming into bearing age is increasing. The commercial producers are more discriminating in planting sorts of fruits adapted to special types of soils, and in locating orchards in sections of the United States to which the specific fruit is adapted. The grower of fruits for the family is also becoming more insistent upon growing some fruits and putting into operation the practices essential to production.

The factors aiding the production of fruit are: (1) Selecting the soil, both as to its adaptability and fertility; (2) Observing the principles underlying successful transplanting; (3) Tilling the soil properly; (4) Regulating the moisture supply; (5) Pruning in accordance with the principles known; (6) Spraying for specific enemies; (7) Harvesting at the proper time, and in such a manner that the best quality of the fruit is maintained; (8) Storing well; and (9) Drying and canning so that a maximum amount of fruit may be kept.

The important fruits are the apple, peach, pear, plum, cherry, grape, strawberry, blackberry, raspberry, currant and gooseberry. These fruits are so varied as to size, time of maturity and adaptability that almost every family may grow some fruits, even if they have only a small city lot at their disposal.

The spirit of neglect of the past in growing fruits should be entirely overcome, and from henceforth more fruits should be grown for their food value, their palatableness, and their healthfulness, and for the sake of making the home more satisfactory.

QUESTIONS

1. What is the relative money value of the different fruits of the United States? What are the leading fruits grown in your state? In your county? At your home?

2. What states lead in fruit production? What are the leading fruits grown in the five leading states?

3. What are the advantages of fruit production?

4. Compare in composition milk and apples, oranges and strawberries, grapes and beefsteak.

5. Contrast the producer of fruits for the family and the commercial producer of fruits.

6. What are the factors aiding the production of apples?

7. How would you combat the codling moth?

8. State what specific type of soil is adapted to growing the apple, the grape and the peach.

9. Name the varieties of apples, peaches and grapes suitable for a home orchard.

10. Score fruits according to the fruit score card.

PROBLEMS

1. Report upon the "Storing of Fruits."
2. Report from some bulletin on the "Drying of Fruits."

REFERENCES

Sears, Productive Orcharding.
Bailey, The Principles of Fruit Growing.
Bailey, The Nursery Book.
Gehrs, Productive Agriculture.
Bulletins.

CHAPTER XXXV

CONTROL OF INSECTS

Enemies for all plants. — Insect enemies of plants and animals are found in the home, among animals, in the field, in the garden and in the orchard. There is no plant or animal that has not its enemies — its fungous enemies, its insect enemies and its disease enemies. Some of the more common animal enemies are treated in other sections. Only the garden and orchard enemies will be discussed in this chapter. However, the principles of insect control discussed in this chapter apply to the insects of the field crops. And the purpose of this chapter is to explain the points essential to insect control, in accordance with the spirit of the book; namely, as an item in securing greater and more economic yields.

Destruction wrought by insects. — No one can tell with exact accuracy the damage insects do. For the losses due to insects are not always directly visible by the death of plant or animal. Many plants, if not practically all plants, are handicapped in their greatest productiveness by either insect or fungous enemies. Rusts, blights, bacteria and insects, sometimes one, and sometimes more, attack the plant. It is the belief of the best authorities that at least 10 per cent of the possible total value of all crops is destroyed by insects.

Farm crops are worth almost $10,000,000,000 annually; if the loss due to insects is 10 per cent, then $1,000,000,000 is lost yearly. This enormous loss is equivalent to twice the value of the entire corn crop in 1917, and twice the combined worth of all wheat, oats and hay crops for the same year. One billion dollars would run the state government of Missouri for almost 100 years.

Preventive measures. — Crop rotation is one of the most important measures to keep down insects. There are many insects

FIG. 185. — An example of a biting or chewing insect.

which attack only one kind of plant. However, in the case of related plants, the enemy of one may attack its related crop the

following year. Rotation of crops tends to combat and destroy a particular insect. Fall plowing helps in preventing insects because many insects have their winter quarters where they fed through the summer. Rubbish along fences should be destroyed, for it harbors insects. Vigorous growth of plants is conducive to overcoming the bad effects of insect life.

FIG. 186. — An example of a sucking insect (San José scale).

Birds aid greatly in the control of insects. There is scarcely a bird that does not destroy insects. Birds should be encouraged to make their habitat upon farms. Boxes may be built in such a form and color that birds will desire to make their homes in them. The laws of the land should be more carefully executed in protecting birds, but an appreciation for birds is more essential to their multiplication than a slavish observance of the law.

Combating insects. — *From the standpoint of control there are two classes of insects: biting insects and sucking insects.*

1. *Biting insects.* — All biting insects have biting mouth-parts used in biting or chewing the vegetation upon which they subsist. The picture on page 515 is representative of the eating habits of this class of insects.

The army worm, potato bug (Colorado beetle), cabbage worm, striped cucumber beetle, various cutworms, blister beetle and grasshoppers are examples of biting insects. All of these insects are combated by a poisonous insecticide, such as arsenate of lead or Paris green. The composition and use of this insecticide will be discussed in a later paragraph.

2. *Sucking insects.* — Sucking insects have a long sucking mouth part (proboscis), and can draw their foods from the stem or leaf of the plant without taking the poisons sprayed on the

surface of plants. For these a contact spray must be employed. Figure 186, opposite, shows a sucking insect.

All plant lice, aphids which attack flowers and fruits, and the San José scale are sucking insects. Contact insecticides must be employed.

Insecticides. — Insecticides are of two kinds; namely, stomach poisons for biting insects, and contact sprays for sucking insects.

1. *Stomach poisons.* — Arsenate of lead is the most common, and the most authoritatively recommended stomach poison. However, Paris green is occasionally used. Arsenate of lead has the following advantages over Paris green; it adheres to the foliage better and longer, mixes with the water solution more satisfactorily, is just as deadly, and is usually cheaper and does not burn foliage.

Arsenate of lead spray is made as follows:

Arsenate of Lead

Arsenate of lead, 3 to 5 pounds (paste)
Or,
Arsenate of lead, 2 to 3 pounds (powder) } to 50 gallons water.

Paris green spray is made as follows:

Paris Green

Mix 2 pounds Paris green to 50 gallons of water.

Arsenate of lead in smaller quantities is made by mixing 3 tablespoonfuls of arsenate of lead to 1 gallon of water. The powdered form of lead arsenate is handled much more easily than the paste and is therefore recommended.

2. *Contact sprays.* — Self-boiled lime sulphur is one of the best contact sprays and is used for the Brown Rot.

To make this spray slake eight pounds of quicklime in two or three gallons of water, and while the lime is slaking sprinkle the powdered sulphur into it. Stir constantly while slaking. Dilute to 50 gallons of water. Strain before using. It requires about an hour to make the solution. Its composition is as follows:

Self-Boiled Lime Sulphur Spray

Quicklime	8 to 10 pounds
Sulphur	8 to 10 pounds
Water	50 gallons

The dormant spray used for the San José scale has about three times the strength of the above spray.

Kerosene emulsion is also a good contact insecticide. It is especially effective for the control of plant lice and aphids. It is made as follows:

Kerosene Emulsion

Hard soap	½ pound
Hot water (soft)	1 gallon
Kerosene (coal oil)	2 gallons

Dissolve the soap in hot water by boiling, and when it is dissolved add the kerosene.

Commercial tobacco extract, tobacco dust or Black Leaf 40 are valuable repellents and contact sprays. These may usually be had directly from the tobacco factories or at the drug stores.

Bordeaux mixture is used for the prevention and control of fungous diseases such as apple scab, potato blight and leaf spot on tomatoes, and for soft bodied sucking insects. Bordeaux mixture is made by dissolving four pounds of copper sulphate in about two gallons of water, and slaking four pounds of lime in a separate vessel of two gallons of water. The above figure illustrates the method of making the copper sulphate and lime solutions.

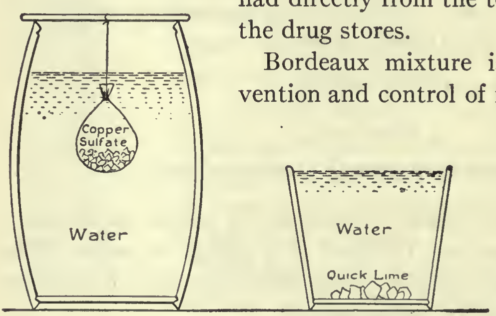


FIG. 187. — Making Bordeaux mixture. Copper sulphate and the quicklime are dissolved in separate vessels of water for about 24 hours, then they are poured together, and water is added to make the solution of proper strength.

The copper sulphate is suspended in a cloth in the water for

24 hours. The lime is likewise slaked in a separate vessel for about 24 hours. Then the solutions may be mixed and sufficient water added to make 50 gallons of the solution. The copper sulphate solution and the lime solution should not be mixed until the day upon which they are to be used. The spray is known as a 4–4–50 Bordeaux mixture spray.

Complete sprays. — A complete spray will combat both insect and fungous enemies. If, for illustration, apples are sprayed for both the codling moth and apple scab, then the regular arsenate of lead spray plus the Bordeaux mixture will combat both enemies. However, the water used in making the Bordeaux mixture must not be used in the complete spray unless all chemicals are doubled. Likewise potatoes may be sprayed with the regular arsenate of lead for the Colorado beetle, and if Bordeaux mixture is added it will also combat the potato blight. If sucking and biting insects and fungous enemies all are on the plant, such spray materials must be compounded to destroy each enemy. Making and using complete sprays saves labor.

Spray calendar. — The following spray calendar is included, because of its compactness, as a ready suggestion on what to do, for in combating insects it is advantageous to do the work early. Completeness is not claimed.

SPRAY CALENDAR

CROP INJURED	INSECT	PROPER TIME TO SPRAY	WHAT INSECTICIDE TO USE
Potatoes Tomatoes	Colorado potato beetle	As soon as signs of insect appear.	Arsenate of lead, three tablespoonfuls to 1 gallon of water.
Cabbage	Cabbage worms	As soon as signs of insect appear and about 10 to 14 days thereafter.	Same as for potato bug, plus, making the water soapy.
Cucumber Melons	Cucumber beetle	As soon as injury appears.	Same as above spray for cabbage worm.
Almost all garden crops	Blister beetle	When the beetles appear.	Arsenate of lead. $2\frac{1}{2}$ pounds of powder to 50 gallons of water.

SPRAY CALENDAR — *Continued*

CROP INJURED	INSECT	PROPER TIME TO SPRAY	WHAT INSECTICIDE TO USE
Cabbage, Radish, Turnips . .	Harlequin cabbage bug	When the insect appears.	Kerosene spray. ½ pound laundry soap, 12 gallons water, and 2 gallons of kerosene.
Cucumbers, Melons, Cantaloupes, Squashes	Squash bug	When the bug appears.	Use the above kerosene spray.
Flowers and garden crops	Aphids or plant lice	When the lice are first seen. Repeat every three to five days.	Kerosene Emulsion. 5 per cent solution, or 1 gallon kerosene to 12–15 gallons water, plus 2 pounds soap; or Black Leaf 40.
Apples . . .	Codling moth	Just before trees bloom. When blooms drop off, and every 3 to 5 weeks thereafter.	Arsenate of lead. 2 pounds to 50 gallons water.
Apples . . .	Apple blotch and apple scab	Same time as above for codling moth.	Bordeaux mixture, 4–4–50.
Potatoes . .	Blight	When plants are well up and about every 10–14 days thereafter.	Bordeaux mixture. Bordeaux mixture plus arsenate of lead for beetles and blight.
Tomatoes . .	Tomato leaf spot	Before disease appears and repeat at 10-day intervals.	Bordeaux mixture.
Peaches . . .	San José scale	Early spring before the leaves appear. Known as a dormant spray.	Boiled lime sulphur spray.
Peaches . . .	Brown rot, peach scab	When blossoms have fallen. Again three or four weeks later.	Self-boiled lime sulphur spray.
Grapes . . .	Black rot	Spray when third leaf appears; again when blooms open; and twice later at intervals of 2 to 3 weeks.	Bordeaux mixture.
Plums . . .	Plum curculio	When petals begin to fall.	Lead arsenate spray.

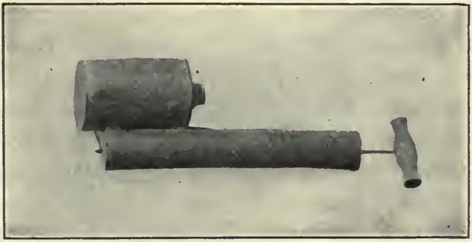


FIG. 188. — A small hand atomizer spray. May be used in small gardens.

Spray machinery. — Spray machinery ranges in size from small hand atomizers to large power sprays. The small hand spray is shown in figure 188.

This spray may be used on flowers and other plants where only a small amount of spraying is to be done. In case orchards are to be sprayed a larger spray must be used.

FIG. 189. — A barrel spray used in small orchards.

Summary. — Insects of various kinds lay an annual tax of $1,000,000,000 upon our nation. How to prevent this large leakage is one of the important problems for our farmers, gardeners, and statesmen. The two classes of insects from the standpoint of control are biting insects and sucking insects. The former are controlled by stomach poison sprays, and the latter by contact sprays. Arsenate of lead is highly recommended as a stomach poison spray. Lime sulphur and kerosene emulsion are an excellent contact spray, having somewhat different uses. Bordeaux mixture is an excellent fungicide and prevents blights (excepting pear blight), leaf spots and scab. The spray calendar given in this chapter is convenient for ready reference. Concerted organized community efforts are often essential to complete success in the combating of insects.

QUESTIONS

1. Name five insects each of field, orchard, garden, animals and the home.
2. How would you combat the house fly?
3. Potatoes often die suddenly — what is the cause and what is the remedy?
4. Discuss two insects that are beneficial.
5. How would you combat the insects which defoliate gooseberries and shade trees?
6. How would you combat the plant lice often found on grapes and on house flowers?

PROBLEMS

1. Report on the usefulness of birds in insect control.
2. Report on the method of controlling lice and parasites of farm animals.

REFERENCES

1. O'Kane, Injurious Insects.
2. Bailey's Cyclopedia of America Agriculture, Vol. II.

SECTION V. FARM MANAGEMENT

CHAPTER XXXVI

PROFITABLE FARMING

Factors in profitable farming. — There are many elements that are fundamental in profitable farming. Some of these, such as good soils, proper tillage, productive plants and good types of farm animals, have already been discussed. Other factors, such as good roads, nearness to market and proper management of land and labor, will be discussed in later chapters.

The outstanding factors in profitable farming, which will be discussed in this chapter, are: (1) Size of the farm; (2) Amount of capital invested; (3) Diversification of farming; (4) The crop yield; (5) Adapting the type of farming readily to changing economic conditions; (6) Use of machinery, and (7) The farmer himself.

1. *Size of farm.* — One of the most important factors in making a profit on the farm is the magnitude of the business. Very small farms generally do not yield as good returns as do large farms. The fact is, that the income above all expense, interest on money invested, depreciation, etc., is almost directly proportional to the size of the farm. This is well shown in the following table, based upon surveys made of farms in Indiana, Illinois and Iowa (1) U. S. Yearbook, 1913.

Relation of Size of Farm to Farm Income

Number of Farms	Size Limits	Average Size Acres	Farm Income	Number of Farms	Size Limits	Average Size Acres	Farm Income
32	1–40 A.	37.4	$ 416	31	160–200 A.	179.1	$1956
51	40–80 A.	72.9	848	36	200–280 A.	239.8	2738
48	80–120 A.	106.9	998	19	280–400 A.	321.8	2838
44	120–160 A.	149.4	1468	12	400–1250 A.	6238	6182

It will be noted from this survey, covering a large number of farms, that the yearly income above all expense becomes larger as the size of the farm increases. For illustration, farms ranging from 40 to 80 acres yielded $848 labor income; while those about twice that size (120 to 160) yielded $1468.

Why is the income from a large farm greater than that from a small farm?

(1) It requires little, if any, more machinery to cultivate 80 acres than 40 acres. If this is true, then the cost of machinery is one-half as great per acre for the 80-acre farm as it is for the 40-acre farm. The following quotation is pertinent here:[1]

"A recent study of machinery equipment on over 1100 farms in western New York showed that when, for instance, a sulky plow was used to cover 15 acres annually the cost per day of use for the machine alone was 83 cents. When this same plow was used to cover 55 acres annually the cost was reduced to 57 cents per day. A grain drill when used to cover 20 acres annually cost per day used, $2.97; when used to cover 117 acres annually the cost per day dropped to $1.04. A grain binder, when used to cover 15 acres per year, cost per day used the surprising sum of $8.15; when used to cover 85 acres per year, the cost per day used was $2.41."

(2) There are usually about as many horses on the 40-acre farm as on the 80-acre farm. In other words, the horses on the 80-acre farm cultivate twice the acreage of the horses on the 40-acre farm. This means a greater production cost per acre for the smaller farms.

(3) The cost of man labor is less on large farms than upon small farms, for the number of acres tilled per man is much greater on large farms than upon small farms. The area farmed per $100 worth of labor in Livingstone County, New York, follows.

(4) The capital invested in farm buildings is usually almost as large on a 40-acre farm as on an 80-acre farm. This fact causes the acreage selling value of the 40-acre farm to be greater than that of the 80-acre farm, and means that the production must be greater to offset the interest on the additional money invested per acre in the smaller farm.

[1] U. S. Yearbook of Agriculture, 1915.

ACRES TILLED PER MAN ON 586 FARMS

Acres	Acres Farmed per $100 Worth of Labor
30 or less	5 acres
31–60	12 acres
61–100	18 acres
101–150	22 acres
151–200	26 acres
Over 200	30 acres

(5) Some have thought that small farms are conducive to greater acreage yields. It is, however, not necessarily true, as the following data will show:

SIZE OF FARMS AND ACREAGE YIELDS — 586 FARMS

Acres	Yield per Acre		
	Oats Bushels	Potatoes Bushels	Hay Tons
30 or less	35	117	1.38
31 to 60	32	111	1.36
61 to 100	32	119	1.33
101 to 150	34	114	1.35
151 to 200	32	127	1.24
Over 200	35	113	1.24

It will be noted that the large farms yielded almost as much per acre as did the small farms.

To conclude, we may say that many farms in the corn belt, ranging from 200 to 300 acres, have proved to be a good working unit and have brought better returns than small farms, and that small farms are not a panacea to cure all the ills of farm life, as some radical economists and city people have advocated.

2. *The amount of capital invested.* — Just as the large farm has its advantages, so does the large investment of capital have advantages over the smaller investment. The term capital, as used in this

section, refers to the value of lands, buildings, stock, implements, etc. The relation of capital to labor income with 578 farms is shown in the following table:[1]

CAPITAL RELATED TO LABOR INCOME

	NUMBER FARMS	AVERAGE LABOR INCOME
$5,000 or less	87	$ 291.00
5,000–7,500	80	407.00
7,500–10,000	112	480.00
10,000–15,000	164	769.00
15,000–20,000	62	1001.00
20,000–30,000	55	1062.00
Over 30,000	18	1691.00

It may be observed from the above data that the labor income increases as the capital increases.

Capital invested beyond a certain point in farm buildings usually decreases the chances for a good labor income. Probably not more than $\frac{1}{4}$ of the aggregate capital invested should be in farm buildings. Capital invested in productive lands and growing stock ordinarily brings good returns.

3. *Diversification in farming.* — A one-crop system has several disadvantages. Some of these disadvantages are as follows:

(1) It constantly draws upon the same plant foods, thus finally impoverishing the soil; (2) It prohibits the distribution of labor. (3) It is more apt to produce and maintain specific enemies of that particular plant; (4) One crop does not provide a balanced ration for any farm animal.

The advantages of diversification in crop production are: (1) Crops require attention at different months of the year. This leads to a proper distribution of labor. One reason many farms do not pay a fair labor income is that the labor is limited to 600 or 1000 hours per year. A farmer can grow corn, wheat and oats

[1] Carver, *Readings in Rural Economics.*

without the one interfering greatly with the labor required by the other two crops. Whereas if oats only were produced, the labor would be confined to March and July mainly, or in other words, to sowing and harvesting. The rest of the year there is no employment, unless other crops are produced. (2) Growing different crops or rotating crops protects to a large degree the fertility of the soil. Different crops take the different elements of plant food from the soil in different proportions. Rotation of crops, therefore, tends to reduce the soil fertility less rapidly than growing the same crop year after year. (3) Diversification of crops produces more nearly a balanced ration. Especially is this true where some of the crops grown are leguminous crops. (4) Diversity of crops and animals seldom results in entire loss through disease or pests.

Surveys have shown that farmers having 6 to 7 sources of income produce greater profits or have a greater labor income than do those farmers having only one or two sources of income, as the following table shows:[1]

Diversity of Enterprise and Labor Income

Michigan Survey

No. Farms	Diversity Index	Average Acreage	Labor Income
27	2 to 3	93	$287.00
46	3 to 4	94	418.00
32	4 to 5	97	436.00
29	Over 5	93	702.00

4. *The crop yield.* — It is not the purpose of this section to advocate in any way intensive methods of crop production. The reason European nations produce almost twice as much per acre as we do in the United States is that each farmer in Europe tills only a few acres. One farmer in the United States cultivates many acres and probably produces 6 to 10 times as large a total yield

[1] U. S. Yearbook of Agriculture, 1913.

as the European farmer does. *It is man yield that we want rather than acreage yield.*

The total production per man in the United States has increased greatly over what it was in 1850. This is due to: (1) Use of larger and more improved machinery; (2) Use of more and larger horses, and tractor power; (3) Removal of stumps and other obstacles; this permits greater efficiency in crop production and harvesting.

The average yields are also increasing, as the following table shows:[1]

INCREASE IN YIELD IN FARM CROPS OF THE UNITED STATES

Average Yield per Acre

	PERIOD 1890–1899 BUSHELS	PERIOD 1906–1915 BUSHELS	PERCENTAGE INCREASE
Barley	23.2	25.6	10.3
Corn	24.1	28.6	10.4
Wheat	13.2	14.9	12.8
Oats	26.1	30.2	15.3
Rye	14.0	16.4	17.1
Potatoes	70.4	97.4	38.2

It is believed that the increase of acreage yields is due to better seed selection, testing seeds, use of adaptable varieties, better methods of crop cultivation, use of manures, and rotation of crops. It is also hoped that the soil will be husbanded more carefully and that the factors essential in building up its fertility will be carefully employed. Then, when all the factors conducive to greater crop yields are supplied, the profits from the farm will be augmented, so that the necessities of life, including a broader agricultural education, may be supplied.

5. *Meeting changing economic conditions.* — Prices of farm products vary to a considerable extent from year to year and even within the different months of the year. The farmer who fore-

[1] U. S. Yearbook of Agriculture.

sees these changes modifies his farm operations to supply in part the demand which creates higher prices. For illustration, some of the farmers foresaw that the world war of 1914 would create conditions that would render inadequate the wool supply. Hence, they began to increase their flocks of sheep. This brought them fair returns, for prices of both wool and mutton were strong, and for the most part scaling upward. The increased flocks were mutually beneficial to producer and consumer, for it increased the profitable labor income of the producer and helped not only to lower the prices to the consumer, but also to correct the cause creating high prices.

During the same war period labor upon farms became scarce. Farmers in many instances began to increase their pastures and herds of beef cattle. This was adapting or modifying the type of farming to changed economic conditions, and helped greatly in solving the labor problem. Another way in which the labor situation was met to a large extent was by the use of tractors. These were often driven by women and in some cases by persons unable to follow walking machinery and handle horses.

Government publications and agricultural papers aid the farmers greatly in foretelling what crops and products they may emphasize in their farm operations. These suggestions may well be heeded in modifying farm operations, for to do so benefits both producer and consumer.

6. *Farm machinery.* — The use of improved farm machinery is recent. The following quotation from Carver's *Selected Readings in Rural Economics* is pertinent: "As late as 1850 according to the census statisticians for agriculture, the old cast-iron plows were in general use, grass was mowed with the scythe, our grain was cut with the sickle or cradle, and thrashed with a flail." Prior to 1850, the cotton gin and a crude cast-iron plow were the only two farm implements used to any great extent; however, the patent for McCormick's first reapers was granted in 1834.

Farm machinery was invented rapidly after the Civil War. And the farmers who did not use the improved types of farm ma-

chinery could not compete in crop production with those using good machinery. The following illustration, taken from the report of the Department of Labor, shows how machinery has helped to produce farm crops more economically.

USE OF MACHINERY IN ECONOMIC CROP PRODUCTION

Kind and Quantity of Crop Produced and Kind of Work Done	Year of Production		Time Worked			
	Hand	Machine	Hand		Machine	
			Hrs.	Min.	Hrs.	Min.
Wheat, 20 bushels wheat (1 acre)	1829–1830	1895–1896	61	5	3	19
Corn, 40 bushels husked (1 acre)	1855	1894	38	45	15	8
Oats, 40 bushels oats (1 acre)	1830	1893	66	15	7	5
Barley, 30 bushels barley (1 acre) . . .	1829–1830	1895–1896	63	35	2	42
Rye, 25 bushels rye (1 acre)	1847–1848	1894–1895	62	59	25	10
Potatoes, 220 bushels (1 acre)	1866	1895	108	55	38	0
Rice, 2640 pounds rough (1 acre) . .	1870	1895	62	5	17	2
Cotton by hand, 750 pounds; by machinery, 1000 pounds 1 acre seed cotton . .	1841	1895	167	48	78	42
Timothy hay harvesting, 1 ton (1 acre) .	1850	1895	21	5	3	56

It will be noted that machinery is helping greatly in saving labor, and in reducing the cost of crop production.

The traction engines in operation in the West pulling 16 ten-inch plows, 4 six-foot harrows, and a wheat drill at the same time, sow from 50 to 75 acres of wheat daily. The tractors are coming into general use. Improved machinery of various kinds is a great factor in making farming profitable. However, it should be

stated that unnecessary farm machinery reduces the chance for profitable farming.

Many farmers have $400.00 worth of machinery on a 40-acre farm, which is $10.00 worth of machinery per acre. The money in farm machinery per acre decreases usually as the size of the farm increases.

It is possible to put too much money into ´arm machinery. If a complete outfit — tractor for illustration — costs about $1000.00, it is not expedient to purchase it for a 40-acre farm, for the number of horses kept will be almost as many as were kept before the tractor was purchased. There are many small farms, and certain types of farms, where a pair of horses is a much greater asset for money making than an automobile and a tractor.

7. *The personal factor in profitable farming.* — There are innumerable things which affect profitable farming. They present problems which cannot be solved except by the man who is on the job, and who can examine and survey all the factors which are essential to success in that particular case. Here is where the thought, the learning and the judgment of the farmer are put to the acid test. It spells the difference between success and failure. Some farmers might be given a farm of the correct size, started with the proper amount of capital invested, be shown how to rightly diversify crops, have pointed out to them the factors essential to good yields, possess the keen discerning judgment to detect the future markets, be provided with the best and most suitable machinery, and yet fail, because they lack the necessary personal qualities. The personal element is a large factor in making the assets overbalance the liabilities. There are men upon farms now where the factors indicating success are almost absent; but because of industry, economy, thrift, frugality, business ability and judgment they succeed in spite of adverse circumstances. On the other hand, some farmers fail under the best of conditions. In the last analysis the farmer himself and his family are largely the determining factor in making the farm a successful enterprise.

Summary. — There are many factors essential in making farming profitable. The most fundamental factors are: (1) Size of the farm, larger farms being more profitable than small ones; (2) The amount of capital invested; larger capital especially when invested in land and growing stock brings better returns than a small investment; (3) Diversification, causing the income to come from 6 to 7 sources; (4) Increasing crop yields; (5) The farmer adapting his farm operations quickly to changing conditions and market demands; (6) The proper use of farm machinery; and (7) The farmer himself.

QUESTIONS

1. Why are the chances for profits better upon a large farm than a small one?
2. If money is worth 5 per cent, what income must be derived from $5000, $10,000, and $15,000 before any profits are realized?
3. Why has a man a better chance to make his labor income greater on a large farm?
4. Why does diversification of farming tend to increase the labor income?
5. Why do farmers produce more in the United States than do farmers in Europe?
6. Discuss farm machinery as a factor in efficient farming.
7. Why is the farmer himself an important factor in profitable farming?

PROBLEMS

1. Report upon the "Efficiency of Machinery" as used in your locality.
2. Compare the conveniences of the owners of large farms with those of small farms.

REFERENCES

Warren, Farm Management.
Boss, Farm Management.
U. S. Yearbook of Agriculture, 1915.

CHAPTER XXXVII

ECONOMIC MARKETING

Importance of marketing. — Although production, preservation, and use of farm products are constantly emphasized in this book, it is worth while to make a few observations on the present general methods of marketing farm products.

Every farmer is interested in making a fair income. This he cannot do unless he heeds the demands of the market, and puts upon the market only products which are in first-class condition. Any one going to the stockyards, to the poultry house, to the mule barn, or to any other place where farm products are bought may readily see that the products sold lack uniformity, condition, quality and finish; that is, they do not meet the demands of the market. These defective practices would often be avoided and other advantages gained by coöperative marketing. In this chapter we shall consider bad practices in marketing and suggest in their place more economic practices.

1. *Uniformity of product.* — If products are to sell well and at the maximum prices, they must possess uniformity. A car or train load of beef cattle, either feeders or those ready for the block, will sell better if they are all one color and are uniform in size and weight. To bring 20 sheep to market, 10 of them in first class condition and 10 in poor condition will lower the price of the good sheep. For if the 10 good lambs, averaging 150 pounds, would sell for 12 cents a pound, they would bring $180; but when they are sold with the group, their selling price is lowered possibly to 10 cents per pound or to $150. And it is certain that the sheep of poor condition will bring no more than they are worth. A matched team, uniform in color, size, breed, condition

and temperament will sell for $50 to $100 more than another team of as good qualities but unmatched in the essential points that make a good team.

Eggs, poultry, apples, potatoes, or other products sold from the farm are enhanced in selling price if uniformity prevails. It is easily possible to increase the selling price of many farm products 10 to 20 per cent by insisting that the product marketed shall be uniform in size, color, quality and finish. The cost of production in many instances is not greater in producing uniform products than products which lack uniformity. The gains made go into the pockets of the producer.

2. *Condition of product when sold.* — All eggs should be clean, fresh, and infertile, if sold for any purpose other than for hatching, and the shell should be free from cracks and dents. Poultry when sold should be in good condition, healthy and well finished. Fruits, potatoes, berries and vegetables should be carefully graded as to size, uniformity, etc., and all those that are bruised, rotten, or disfigured in any way should be sold in a different class. It is poor marketing to sell apples that have the scab, or are disfigured in any way. Likewise potatoes that are scabby cannot be sold to good advantage. If this be true, it behooves the farmer to prevent the causes which tend to reduce the selling price of his products. Products which are off in condition indicate low production, and in addition result in a depreciation in selling value. The farmer thus loses in two ways, and the consumer is compelled to use an inferior product. The farmer probably loses from 15 to 30 per cent on decreased production. The selling price is also lowered.

3. *Quality affects selling value of farm products.* — The sugar mule is no better than the lumber mule except in quality and action, and for these two reasons his usefulness is augmented so that a pair of sugar mules will bring $50 to $100 more than an equally good pair of lumber mules. Quality in a dozen eggs means the best market price, while if they are off in quality they are decreased in value all the way from 20 to 50 per cent. The annual

estimated loss on eggs in the United States because of inferior quality is $45,000,000 and on fowls $75,000,000. It is thought by some that rotten eggs are the only source of loss to the farmer, but we should remember that lack of quality in any product lowers its selling value. Wheat, oats, hay and many other products are sold according to weight and quality. If a bushel of wheat weighed 60 pounds, but was moldy because of getting wet, its selling price would be lowered immediately about one-third, and in many cases it could not be sold at all except for feeding purposes. Quality in seeds, as shown by absence of foreign seeds, dirt, sticks, etc., is a powerful factor in enhancing their selling price. Clover seeds with a few foreign seeds often cannot be sold at all. This is a direct loss to the farmer. Wool is often so full of cockleburs, sticks, weeds, and dirt that its selling price is cut in half or more. The loser in each case is the farmer, and the consumer's wants are not satisfied. From 5 to 15 per cent loss to the average farmer's income is inflicted because he is not careful to add quality to the product he sells.

Everything the farmer sells is immediately classified by the purchaser. The price of eggs throughout the summer is lower than it would be if the merchant knew that all the eggs he purchased were fresh, *infertile*, and of the best quality. Wool, fruits, grains and every other product sold are likewise affected. In some products the quality can be seen; in some it cannot be seen. But the market price is easily known and should stimulate farmers to market a better quality of goods.

4. *Degree of finish affects farmer's profits.* — The St. Louis market price on beef steers on a certain day varied as much as $4.75. The poorest grade sold for $12 per hundredweight; and the best for $16.75. This large variation in selling price was mostly due to a lack of finish. Sheep, swine, mules and horses are somewhat similarly affected in their selling value. The producer sustains most of this loss. However, the consumer is also directly affected, for it results ultimately in a scarcity of product, and hence higher prices.

What are the degrees of finish in farm products upon which the farmer can safely depend to meet the demands of the market and to bring him the greatest profits? Hogs can be safely marketed when they weigh about 200 pounds. It may, however, bring greater economic returns to keep and feed the hog until it approximates 300 pounds. Beef steers are in very good demand when they weigh from 1000 to 1500 pounds, although it may not be economical to keep and feed a steer until he weighs 1500 pounds. But at any event the steer sold for slaughter should be fat, so that the percentage of dressed carcass approaches the maximum that that particular steer is capable of dressing out under the best of conditions. Sheep and lambs are often sold when in poor flesh and finish. It is the belief of the author that a small grain ration fed for six to eight weeks before marketing will make big money for the farmer. It will increase the weight and augment the selling price. All poultry should be fattened and finished before it is marketed.

The degree of finish of any product sold should be consistent with economic production, and with the highest reasonable profits to the farmer. However, the social order should also be remembered, for it is, to a certain degree, wrong to sell and slaughter animals when they are too small. Laws should be enacted which set the minimum age and weight when all different kinds of farm animals may be marketed for slaughter. In several instances (veal, lambs, and poultry for instance), producers should be encouraged to keep animals longer, so that the dressed carcass would be 25 to 50 per cent greater.

5. *Meeting the demands of the market.* — Every producer may well study the demands of the market, for it means profits to the producer and a saving and satisfaction to the consumer. Every article bought from the farm has a certain point at which it conserves the best interests of the producer and the consumer. It is at this point that it ought to bring the greatest profits to the producer and the maximum satisfaction to the consumer. To illustrate, a bushel of sprayed apples will bring

60 cents, whereas a bushel of unsprayed apples will bring possibly 40 cents. Sprayed apples will yield ordinarily twice as much human food as a bushel of unsprayed apples. Consequently both the producer and consumer have profited by the spraying. What is true of apples is true of every product the farmer sells. Some people do not like to cater to the trade, but that it pays to cater no one questions. A small amount of time spent in studying the demands of the market often brings better returns than two additional hours at hard manual work.

6. *Coöperative marketing.* — Coöperation is the spirit of the age and farmers are coming to appreciate the fact that coöperation means a saving to themselves and also to the consumer. It is very costly, clumsy and unbusinesslike for farmers to sell and distribute at long distances the small amounts of the various products produced on their farms. To properly distribute farm products to the places where they will sell best, and at the same time really satisfy the needs of the consumer, is a problem which has not been solved except in one or two instances. If the reader does not know how coöperation in marketing works, he may partially find out by going to his grocer and asking him about the prices of various grades of oranges. He will find that they are well graded as to size and color, and are packed and labeled in a simple manner so that the trade may always know about the grade and price of oranges they are buying. Back of this admirable system of marketing oranges and other citrous fruits is the California Citrous Fruit Growers Association. This organization grades, labels, and markets in the same manner the various grades of oranges it produces. From this plan as practiced by this organization in marketing its products, farmers can learn a great deal. We may learn this, that if any individual farmer is to secure the best prices for his products, these products must have something in common with the products of his neighbors, or in other words, the entire community may produce products that are uniform in size, color, condition, quality and degree of finish. These

products may be sold in a coöperative manner, and the best returns be secured therefrom.

Many cream stations and poultry houses have wagons to collect daily along assigned routes the products of the farmers. This excels the old system, in which the farmer marketed his own stuff at intervals of a week or every two weeks. Where this is done to the best advantage a uniform product is produced by the farmers. From this we may learn that the production of a good uniform product pays.

Summary. — It behooves the farmer not only to be a producer of good farm products, but to be able also to finish and perfect his products so that he may realize a reasonable profit. In order that the farmer may realize the greatest profits he must observe the following points in preparing his products for the market: (1) The product or products sold must be uniform; (2) The thing sold must be in good condition; (3) The quality must be first class; (4) The product must be finished reasonably well if it is to bring economic returns to the producer; (5) Catering to the demands of the market is good business, and increases the farmer's profits; and (6) Products which will yield themselves to coöperative marketing are usually increased in price by disposing of them in a coöperative way. These few principles in selling farmers' products will mutually benefit the producer, by increasing his profits, and the consumer by satisfying his demands.

QUESTIONS

1. Why do products that are uniform sell better than those that lack uniformity?

2. What is meant by quality?

3. What animals are usually not finished well for market in your locality? Discuss the probable loss due to the fact that they are not properly finished.

4. Secure from the station agent the average weight of the hogs, sheep and cattle sold at your nearest railroad station.

5. Do you know of any coöperative effort in your locality in selling and buying? Describe the organization and methods used.

PROBLEMS

1. Report upon the demands of the market regarding the kind of hogs, sheep, cattle and poultry wanted.

2. Discuss the possibilities of coöperative production and marketing in your locality.

REFERENCES

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CHAPTER XXXVIII

FARM LABOR

Efficiency of American farm labor. — The proportion of our population living upon farms is constantly decreasing. The percentage population upon farms in 1880, 1890, 1900 and 1910 was 70.5, 63.9, 59.5 and 53.7 respectively. If the decrease in rural population continues at the same rate, then in 1920 there will be about 46 per cent of our people in the country. All people in towns of 2500 and over are counted as urban population. In 1900 there were 10,382,000 men engaged in agriculture,[1] out of a total population of 79,994,574. In other words, one man engaged in agriculture produced the food for about 7.9 persons. At the present time, farm labor is still scarcer. During the Great War it is quite possible that there was only one producer of farm products to every 10 or 12 consumers. The time may come when one farmer will produce enough to feed six or eight families. This does not, as some people suppose, indicate bad conditions. In China from 70 to 80 per cent of the people are farmers. Yet they cannot feed their own people. They till their land in inefficient ways. They use hoes and sticks. Each farmer takes care of an acre or two of land. Children can't go to school because they must work upon the farms to provide food enough to satisfy their own needs.

In the United States, fortunately, conditions are different. In 1900 the number of acres per person upon farms was 27.0. Large farms are not a curse, they are a blessing. Small farms mean inefficiency and peasantry. The chances for a better civilization are greatly handicapped. The American farmer, because he takes

[1] Crop Report, July, 1918.

care of more land than the European farmer, and because he uses labor-saving machinery, is a great asset in maintaining our civilization. Boys and girls may continue longer in school, or do some other work, because the farmer will provide the food.

The American farmer can send his own children to school longer than any other farmer in the world because he can produce enough to make this possible. Although farmers as a whole are not making big money, their income is fairly safe, and a moderate income is reasonably sure for a number of years to come.

Eras of low and high priced labor. — From 1875 to 1897 farmers' products were low priced. A general business depression prevailed for two reasons: (1) There were too many farmers in proportion to the rest of the population; (2) The fertile lands of the Mississippi Valley and the West were being opened and occupied. Both of these conditions brought an era of overproduction and consequent low prices. Corn and wheat sold for 15 to 25 cents per bushel, and in some cases were unsalable. Hogs and cattle sold for $3.25 to $4.50 per hundredweight. Farmers were not making money and hard times prevailed generally. Labor was plentiful and cheap.

To-day we have reverse conditions. The number of laborers upon the farms is at low ebb, and yet the total of farm products has been somewhat increased, though it is possibly not keeping pace with the increase in population. It is believed by some that prices on the farm products will remain fairly good for several years to come. It is to be hoped that the human race will be fed by our farmers, but that prices will not go down to rock bottom figures, as they did during the years from 1895 to 1897.

There is much of misconception and misapprehension on the part of both the man of the city and the farmer concerning farm labor. Farm labor which will produce the greatest degree of prosperity and comfort for all is desirable. A rational opinion on this problem can be reached only through the consideration of such topics as the following:

1. The cost of farm labor.
2. Factors that tend to bunch farm labor.
3. Factors that tend to equalize farm labor.
4. Factors that make farm labor more efficient.

Cost of farm labor. — In the present age farm labor is scarce and the wages are high. During the period of low prices farm hands could be employed at $10 to $15 per month, and men at harvest time were glad to get work at $1.00 to $1.25 per day. Prices of farm products were correspondingly low. When farm labor is worth $35 to $40 per month farm products are proportionately high. *When farm labor costs much or little, it is the efficient use of the labor at hand which makes for success.*

The opinion that long hours will solve the labor problem for the farm is a mistaken one. That is one of the causes driving laborers away from the farm. Eight hours constitutes the average work day in the cities. And 8 to 10 hours is also sufficient on the farm. The fact is, 2400 hours per year is a big year's work. On 28 farms in Missouri the average working day for one year's time was 9.64 hours. The average hours worked per month were 251.4, and per year 3018 hours.[1] The average number of hours worked by the horses on 24 farms was 1127. This is less than three hours per day. On a number of dairy farms in Minnesota the average work day throughout the year was 8.6 hours; on grain farms 7.4 hours. The above does not include Sunday work. The work on Sunday amounted to 3.4 hours on the dairy farms, and 2.2 on the grain farms.[2]

The cost of man and horse labor may be decreased by providing more constant work and by the use of better machinery.

Factors that tend to bunch farm labor. — The season is the largest factor tending to bunch farm labor. Almost all the work on the production of farm crops must be done during the summer months. The following table[3] gives us a good idea of the

[1] Missouri Bulletin No. 125. [2] Minnesota Bulletin No. 97.
[3] Missouri Bulletin No. 6.

distribution in hours of labor to produce four of the leading farm crops.

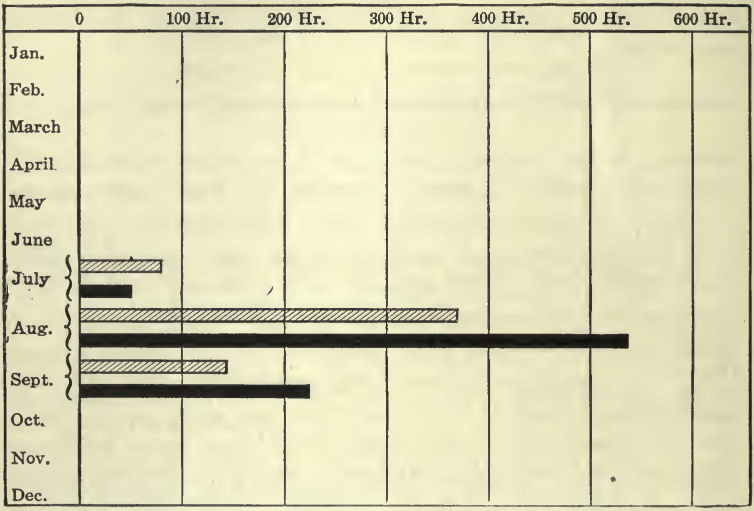
Distribution of Man and Horse Labor per Acre in the Production of Four Farm Crops

	Oats		Wheat		Timothy		Corn		Total for Yr.	
	Man, Hr.	Horse, Hr.	Man, Hr.	Horse, Hr.	Man, Hr.	Horse, Hr.	Man, Hr.	Horse, Hr.	Man Labor for the Year	Horse Labor for the Year
January .							.55	.28	0.55	0.28
February							.48	.10	4.48	0.10
March .	2.92	6.65					.15		3.07	2.65
April . .	1.32	2.93					1.84	4.57	3.16	7.50
May . .	.26	.79					6.38	14.09	6.66	14.88
June . .	1.11	.87	3.2	3.2	.48	.63	6.72	10.91	10.71	25.61
July . .	3.50	3.69	6.4	6.5	6.02	9.02	2.14	3.25	18.06	22.46
August .	1.16	1.29	1.62	3.1			1.84	1.17	4.62	6.56
September	.17	.21	2.70	5.1			5.03	1.73	7.80	7.04
October .			4.2	7.3			.78	.72	4.98	8.02
November			.26	.5			3.14	1.77	2.30	1.82
December							2.55	1.61	2.55	1.61
Totals	10.44	16.42	18.38	25.7	6.5	9.65	31.60	40.20		

It will be noted from the table that above 50 per cent of the hours of labor falls in the months of May, June, July and August. In less than $\frac{1}{3}$ of the time $\frac{1}{2}$ of the work is done. The graph, on page 544, which may be considered a representative graph, shows how labor is bunched in the production of 23 acres of wheat.

The graph shows that almost all the man and horse labor on wheat was done in July and August. So it is with the production of any one crop, all the labor in its production is confined to two or three months of the year.

If the entire farm is devoted to the production of one crop there is bound to be work only for a small part of the year. A well-diversified system of crop production tends to distribute farm labor.



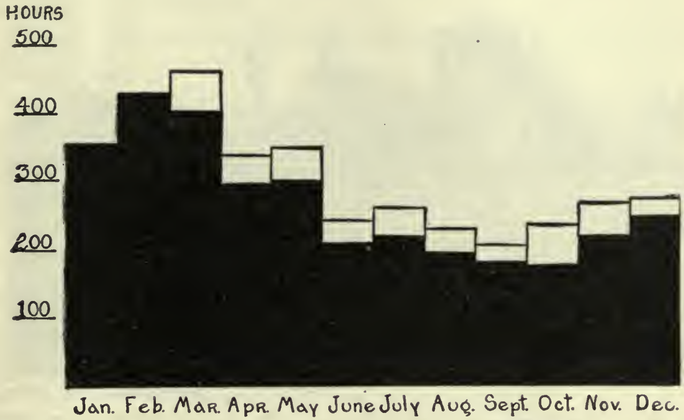
Hours of labor given to 23 acres of wheat. The upper line in each month represents man labor; the lower, horse labor. The black and gray lines represent time given to harvesting, threshing, etc.; the white line, to plowing, etc.

Factors that tend to equalize farm labor. — 1. Diversification of farm operations tends to distribute farm labor, just as the one-crop system tends to bunch labor. To illustrate, the time required for plowing for wheat and harvesting it does not interfere with corn raising. Nor does oat production interfere greatly with either wheat or corn production.

But with all of the foregoing crops farm labor is limited almost wholly to the summer months. If dairying is combined with general grain farming, and possibly poultry and some fruit production, farm labor will be fairly well distributed throughout the year. Twenty dairy cattle demand at least 6 hours daily, and that, supplemented with general crop production, will insure a fair distribution of farm labor. The following graph shows the constancy and uniformity of employment from month to month with 18 dairy cows and 11 other cattle.

2. Even sized fields also help to equalize farm labor. A 160-acre

farm divided into 4 fields of 30 acres each (and the rest in pasture) requires a fairly even distribution of farm labor. Especially is this true where a rotation of crops is practiced.



Distribution of man labor on 18 cows and 11 other cattle. White represents the time used in delivering milk.

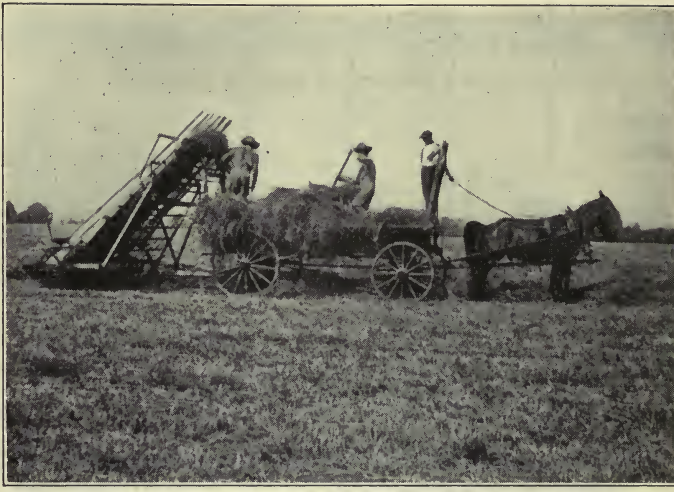
3. Fall plowing helps in equalizing both man and horse labor. Fall plowing is not practiced as much as it should be, and it is hoped that farmers will utilize fall and winter days for plowing when it is possible. The farm tractor may become a factor in the employment of men during winter months.

Factors that make farm labor more efficient. — 1. Farm machinery is one of the greatest factors in making farm labor more efficient and productive. Some of the machines that increase efficiency of labor are the gang plow, section harrow, two row corn cultivator, corn cutter, drill, thresher, huller, hay rake, hay fork, milking machine, electric shearing device, cotton gin, auto truck, tractor, and manure spreader.

The following picture illustrates a labor saving machine.

The following data, taken from the reports of the Department of Labor,[1] give the cost of production of several of the leading

[1] Thirteenth Annual Report.



Courtesy New Jersey Station.

FIG. 190.—Using hay loader at Adelphia, N. J. One kind of labor-saving machinery.

crops, with a definite amount of each crop produced. This material is given as the best available; it is somewhat inaccurate but it is suggestive.

COST OF PRODUCTION BY HAND AND BY MACHINE PER ACRE

	YEARS OF PRODUCTION		COST		PER CENT
	Hand	Machine	Hand	Machine	Decrease
Corn, 40 bushels, 1 acre	1855	1894	$16.34	$6.62	59
Wheat, 20 bushels, 1 acre	1829–1830	1895–1896	4.00	1.12	71
Oats, 40 bushels, 1 acre	1830	1893	3.85	1.60	58
Hay, 1 ton, 1 acre	1850	1895	1.92	0.63	67
Cotton, 750 pounds, 1 acre	1814	1895	6.15	4.71	23
Potatoes, 220 bushels, 1 acre	1866	1895	13.18	5.97	54

It is through farm machinery and large farms that our farmers are enabled to continue to feed our people in spite of the fact that the number of farmers has constantly decreased and our population has constantly increased.

The efficiency of farm labor in America is shown again in the following data:

The following material is a comparison of the production of the farmers of the province of Bavaria, Germany, for 1909, and the farmers of Iowa for 1911. Although the Bavarian farmers produced more per acre, the Iowa farmers produced four times as much per man as the Bavarian farmers. The Iowa farmers on an average produced 86,777 pounds of food per person, while the Bavarian farmers on an average produced 22,231 pounds. This difference is due to the use of machinery and larger fields, — two of the greatest factors in making farm labor efficient. Man yield is what we want in America.

Because of the recency of introduction of farm tractors it may be appropriate to discuss them briefly. Farmer's Bulletin No. 719 gives a summarized statement of the experience of 200 Illinois farmers upon Corn Belt farms. The bulletin should be fully reported upon in class. The following are some observations on the bulletin:

MINIMUM ACREAGES UPON WHICH TRACTORS ARE PROFITABLE

(Averages Based on Estimates of About 200 Illinois Tractor Owners.)

SIZE OF TRACTOR	MINIMUM SIZE OF FARM ON WHICH IT IS PROFITABLE. (OWNERS' ESTIMATE)
2-plow	140
3-plow	200
4-plow	250
5-plow	320

The plows referred to in the above table were 14-inch plows. Thus the 2-plow tractor had two 14-inch plows.

The bulletin thus summarizes the farmers' opinions on the advantages and disadvantages of the tractor.

"The ability of the tractor to do heavy work and to do it quickly, thus covering the desired acreage within the proper season, was considered the principal advantage. The saving of man-labor and the doing away with hired help was placed next. The ability to plow to a good depth, especially in hot weather, was placed third, while economy of operation, the displacement of horses,

Courtesy Rock Island Plow Co. Ill

FIG. 191. — A tractor in many instances saves time, labor and money. It is suited to work in large, level fields. Besides the tractor will do other beltwork on the farm.

and the ability to use the tractor day and night were not mentioned by very many owners, although they are usually considered, theoretically, to be decided advantages. Under disadvantages, difficulty of efficient operation and packing of the ground when damp were the principal points. Expense came next, while delays and inability to use the tractor for many kinds of work for which horses could be used were given by several owners. While other advantages and disadvantages were mentioned, they were not given by a large number of owners."

Farmer's Bulletin Number 963 states that the average life of tractors ranges from 7½ years to 8 years, and that the average number of days tractors are used per year is 45. The bulletin itself should be consulted.

2. The proper use of horse power is an important factor in making farm labor efficient. It is estimated that in pioneer days men drove one small 800 pound horse to a single shovel, but to-day one man will drive three or four big, 1200 to 1400 pound,

Courtesy of Minn. Extension Bu

FIG. 192.—A team of mares, which, properly cared for and allowed to raise colts each year, furnish an economical form of motive power.

horses to large machinery. In other words, the man driving several horses does about 5 to 8 times as much as one man did in pioneer days. Larger fields clear of stumps, and larger machinery and horses, have multiplied the efficiency of farm labor. The above figure is given as representative of the efficient use of horse power.

One or more good pure-bred brood mares, the number kept depending upon the size of the farm, will provide economical horse power. These mares will do an abundance of work and will raise a colt occasionally. This will reduce the cost of horse labor.

3. The size of farms is an important factor in making farm labor efficient. The relative efficiency of farm labor and size of farms is shown in the following table:

SIZE OF FARM AND LABOR EFFICIENCY

586 Farms

ACRES	AVERAGE ACREAGE	RECEIPTS PER ACRE	LABOR COST PER ACRE	RECEIPTS MINUS LABOR PER ACRE	NET PROFIT PER ACRE
30 or less . .	21	$26.14	$19.90	$6.24	Loss, $7.52
31–60 . .	49	14.24	8.10	6.14	Loss, 1.47
61–100 . .	83	12.49	5.60	6.89	Gain, 0.57
101–150 . .	124	11.56	4.54	7.02	Gain, 0.89
151–200 . .	177	10.89	3.92	6.97	Gain, 1.75
Over 200 . .	261	10.93	3.33	7.60	Gain, 2.38

Small farms of 30 acres and less cost $7.52 per acre, while farms of 200 acres and over made $1.38 per acre.

More than that, the number of acres cultivated per $100 worth of labor was greater on the large farms than on the small farms, as the following table taken from the same source well shows.

SIZE OF FARM RELATED TO EFFICIENCY OF FARM Labor — 586 Farms

ACRES	AREA FARMED PER $100 WORTH OF LABOR
30 or less	5 acres
31 to 60	12 acres
61 to 100	18 acres
101 to 150	22 acres
151 to 200	26 acres
Over 200	30 acres

If the two tables are compared, it will be seen, not only that the number of acres taken care of per $100 worth of farm labor was greater on larger farms, but that the net profit per acre was also greater on the larger farms, showing that large farms are conducive to greater efficiency on the part of labor.

There has been a tendency in recent times for farms to increase in size. This is shown in the following table, taken from census reports.

AVERAGE SIZES OF FARMS GIVEN IN ACRES IN THE UNITED STATES

	1910	1900	1890	1880	1870	1860	1850
United States	138.1	147.0	136.5	133.7	153.3	199.2	202.6
North Atantic States	95.7	97.5	95.3	97.7	104.3	108.1	112.6
South Atlantic States	99.3	109.1	133.6	157.4	241.1	352.8	376.4
North Central States	156.9	145.2	133.4	121.9	123.7	139.7	143.3
South Central States	131.2	156.0	144.0	150.6	194.4	321.3	291.0
Western Division	296.9	393.5	324.1	312.9	336.4	366.9	694.9

It will be noted that from 1850 to 1880 the average size of farms became constantly less; that from 1880 up to 1900 they became larger; and that from 1900 to 1910 they became somewhat smaller.

The farms near towns are becoming smaller. The farms out in the country are growing larger. But since large farms are more efficient, the tendency is for farmers having large farms to purchase more land; and the reverse is true of those owning small farms.

4. A working day schedule aids in making farm labor more efficient. Planning work for rainy days and severe weather increases the efficiency of farm labor from 10 to 25 per cent. On such days the farmer can clean seeds, clean farm buildings, repair farm machinery, sharpen tools and sickles, oil wagons and machinery, do blacksmithing, sharpen fence posts, repair gates and the interior of farm buildings, etc. Such a schedule memorandum should be kept constantly, for it increases the efficiency of farm labor.

5. Reading agricultural publications is another factor which increases the efficiency of farm labor. The following, taken from Henry and Morrison, *Feeds and Feeding*, is based on a survey made by *Hoard's Dairyman.* It gives interesting information on the relation of reading dairy literature to the dairyman's profits.

VALUE OF READING DAIRY LITERATURE

	NUMBER COWS	ANNUAL YIELD OF BUTTER FAT	COST OF FEED	GROSS RETURNS	RETURNS OVER COST OF FEED	RECEIVED FOR $1 FEED	FEED COST OF BUTTER FAT PER POUND
Owners reading dairy papers	6202	185.0 lb.	$34.78	$49.32	$14.54	$1.42	17.54
Owners not reading dairy papers . .	9122	136.7 lb.	35.00	36.85	1.85	1.05	28.84

It will be observed that reading dairymen were better dairymen, for they produced one pound of butter for 17.5 cents; while those not reading dairy papers paid 28.8 cents per pound of butter fat produced.

Summary. — Farm labor has become scarcer within recent years, and hence higher priced. On the other hand, farm labor is more efficient in the United States than elsewhere. The American farmer produces 4 to 5 times as much human food as the average European farmer. This has prevented peasantry, poor homes, and a low stage of civilization. Prosperous farmers mean general prosperity. When the farmers fail, all fail.

The factors which tend to bunch farm labor are: (1) The seasons; (2) Unequal sized fields; (3) The production of one crop. On the other hand, the factors which tend to equalize farm labor are: (1) Diversification of farm operations; (2) Even sized fields; (3) Winter plowing.

The factors which make farm labor more efficient are: (1) Farm machinery; (2) The use of more horse power; (3) Large farms; (4) A working schedule; (5) The reading of agricultural literature.

QUESTIONS

1. Why is American farm labor more efficient than European labor?
2. What factors tend to bunch farm labor?
3 What are some things that will tend to distribute farm labor?

4. Discuss some farm machine as a saver of labor.
5. What things aid in making farm labor more efficient?

PROBLEMS

1. Give all the reasons why a small horse or mule is more economical, considering cost of crop production, on small farms than a large horse.

2. Bring together all the data available on the advantages of larger farms. Substantiate each general statement made with specific data.

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Gehrs, Productive Agriculture.
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CHAPTER XXXIX

PLANNING THE GARDEN AND THE FARM

Gardens and farms often poorly planned. — Many gardens and farms are not well planned, and are therefore not conducive to economy of production, convenience, and the saving of time. Streams, hillsides, roads, and new clearings have often determined the shape and size of pasture and field. In many instances no thought has been given to replanning. But it may be appropriately said that planning pays. The old statement is doubtless true, "A man from his shoulders down is worth $1.50 a day, and it is difficult to estimate his worth from his shoulders up, for this depends upon what he has in his heart and his head." It is likewise true that headwork in planning a farm brings good returns. In other words, the farmer who reads, thinks, or plans an hour or two a day usually makes more money, and produces more and better products than the man who works slavishly every hour of the day. Reading, thinking and planning pay dividends of two sorts — satisfaction and cash.

Planning the garden. — A garden may be poorly planned, as shown in figure 193, or it may be well planned, as shown in figure 194.

This garden is poorly planned or not planned at all. (1) Almost one-half of the land is taken up by paths, which are the best chimneys that can be constructed for carrying off soil moisture. (2) The rows are short and about the only tool that can be used is the hoe. (3) Only about $\frac{3}{5}$ as much can be produced as on a well-planned garden, and that at a greater expenditure of time and labor.

The replanned garden is organized better: (1) It utilizes more

nearly every square foot of the garden. (2) The absence of paths helps to conserve all the moisture. (3) The hand plow or the horse and plow may be used. This saves time and energy and

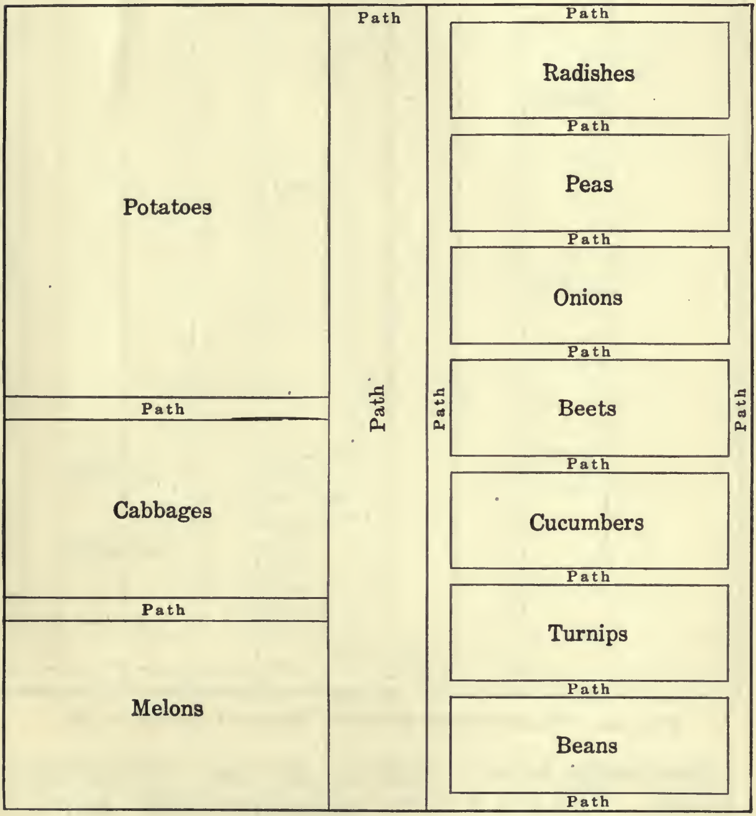

FIG. 193. — Poorly planned unorganized garden. (Last year's plan.)

the garden gets better tillage. This reduces the cost, increases the yield and makes the garden more satisfactory. This garden as replanned yielded in one year 50 to 75 per cent more vegetables than did the old garden.

Potatoes	Sweet Potatoes	Cabbage	Melons Cucumbers	Peas	Radishes	Onions	Beans	Beets	Sweet Corn

FIG. 194. — The above garden replanned. Method of cropping this year.

Reorganizing farms. — Farms are often laid out according to accident. This fact is shown in the representative picture on page 557.

This farm does not show the best organization. (1) It has two square fields. It requires more time to till square fields than long rectangular ones. (2) The two square fields are not directly accessible to the farmstead. (3) The plan is poorly adapted to a well-organized system of crop rotation.

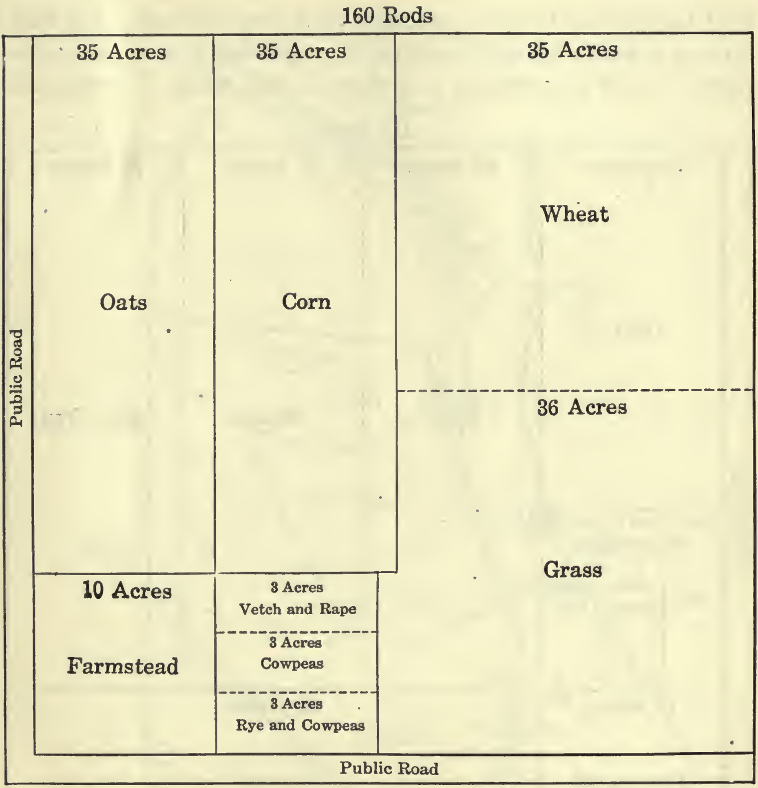

FIG. 195. — 160-acre farm fairly well organized. The way it was formed for a number of years.

The same farm was replanned and is now worked according to the figure shown on page 558.

The reorganized plan has the following points in its favor: (1) The fields are long and rectangular, which saves labor in tillage; (2) The fields are more accessible from the farmstead and the distance to the fields in one round trip is only 160 rods, whereas in the original plan it was 240 rods. The additional 80 rods, or one-half mile, in the various trips made in going to and from the

field throughout the year amounts to a large mileage. (3) The farm as it is now operated is suited to a better system of crop rotations. (4) It is conducive to greater diversification of crops, and

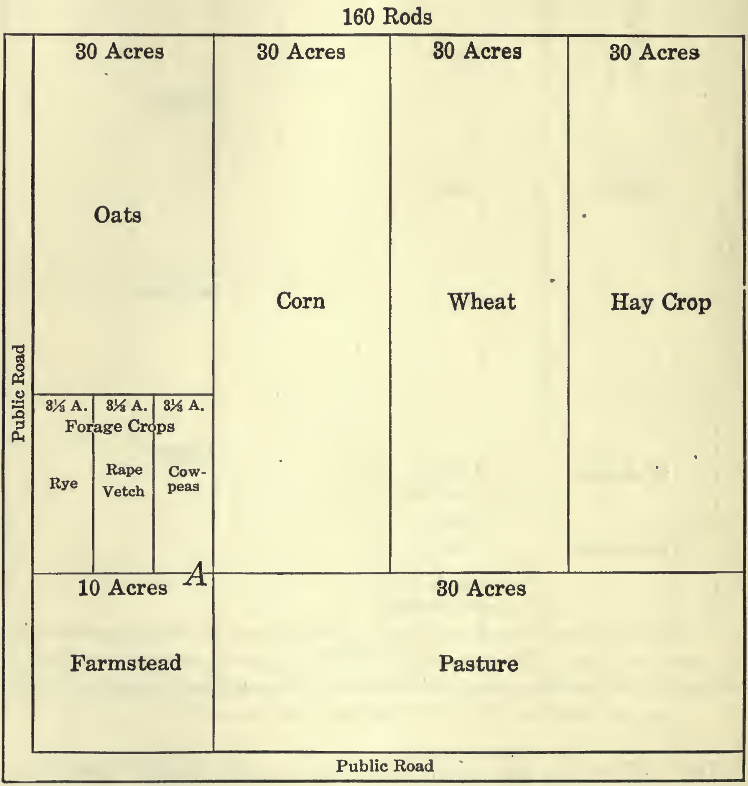

FIG. 196. — The above form reorganized showing a better plan than it did under previous years of management.

hence a surer income. (5) It makes for a better distribution of labor and income.

The following figure shows the diagram of a farm as it was before it was remodeled by the office of Farm Management of the United States Department of Agriculture.

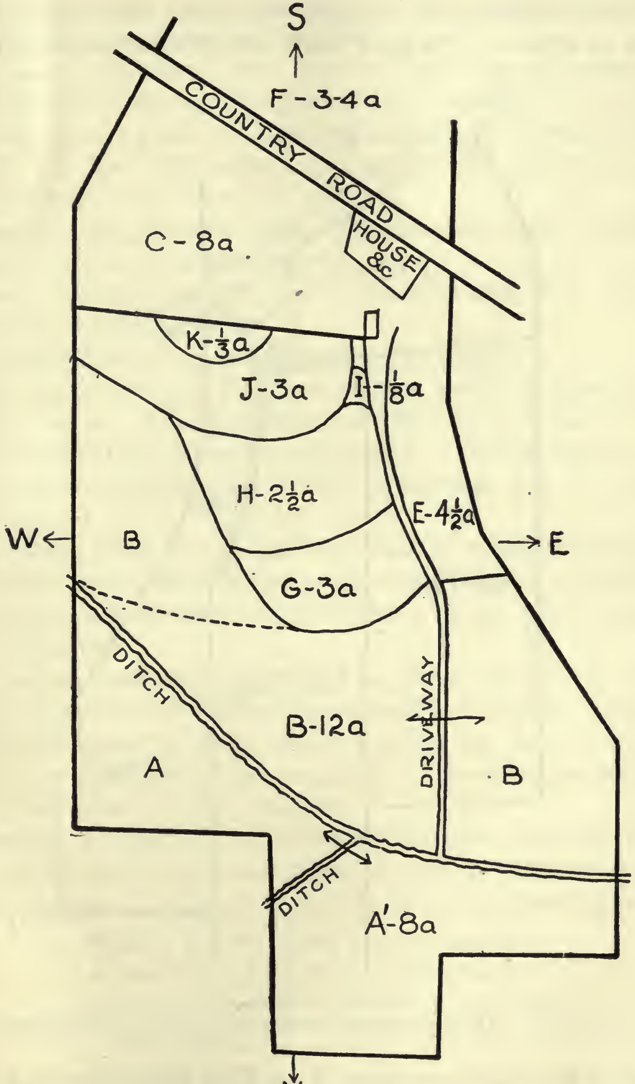

FIG. 197. — A poorly laid out farm.

This farm presented complicated outlines which made it difficult to replan. The open ditch, the driveway and the country

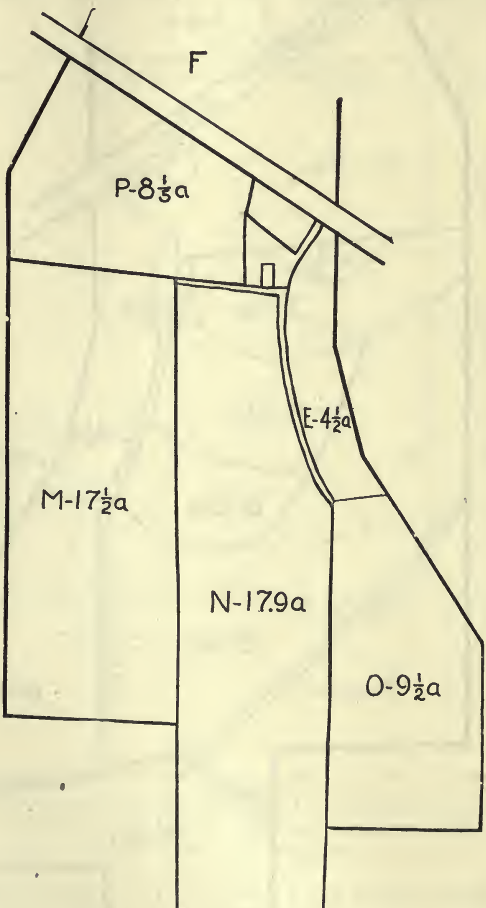

FIG. 198. — This is the reorganized farm shown in the preceding figure.

road which crosses one corner of the farm made replanning a real problem. But the open ditch was drained by tile and then

closed, a few lines were straightened, and the reorganized farm presented the form shown in figure 198.

The above replanned farm has the following advantages: (1) It makes all fields and the pasture easily accessible; (2) The three fields are long and rectangular, providing for cheapest production; (3) The three fields are about of equal size so that a three-year crop rotation may be practiced.

Suggestions for planning farms. — In planning farms the following points should be remembered:

1. Long rectangular fields require less time and labor to till than square or irregular fields.

2. Regular fields and pastures require less fencing.

3. The more accessible fields and pastures are to the farmstead, the less is the cost of hauling manure and harvesting crops.

4. Well-organized farms are adapted to a better system of crop rotations, and hence the fertility of the farm may be better maintained.

5. Irregular fields may be put into meadow crops or pastures, which, when harvested, require less turning around. There is six times as much turning to be done with a 12-inch plow as with a six-foot mower.

6. The farmstead ordinarily should be placed near the road, for this gives the greatest social advantages possible, an important thing.

7. The well-planned farm makes possible the use of larger machinery. The use of bigger machinery is becoming important, since it lowers the cost of production.

Summary. — Gardens and farms are often tilled in patches and fields that are small, irregular and poorly planned. In many cases replanning pays. The things to keep in mind in replanning are:

1. Making the fields long and rectangular.
2. Accessibility of the fields and pastures.
3. Adaptability of the replanned farm to crop rotations.
4. Cost of fencing.
5. Economy of crop production.

If several of these things can be obtained in reorganizing a farm, then it is possibly wise to reorganize the farm. In some instances it may require several years to get a farm entirely replanned. Drawing the farm as it now is and redrawing it on a new plan often brings an excellent solution of how the farm can best be replanned.

QUESTIONS

1. Why replan farms?

2. State the advantages of the replanned garden shown in this chapter over the unplanned one.

3. What are the advantages of rectangular fields over square fields?

4. Small irregular pieces of land may be utilized more economically with what crops? Why?

5. What seasons of the year may be used to best advantage in reconstructing farms? Why?

PROBLEMS

1. Make a drawing of the present plan of some farm, and state its advantages and disadvantages. If the forms can be replanned, illustrate the new plan with a drawing.

REFERENCES

Bailey's Cyclopedia, Vol. I.
Warren, Farm Management.
Boss, Farm Management.

CHAPTER XL

FARM BOOKKEEPING

Why keep books. — Business men, such as bankers and merchants, keep books. If farmers are to know about their own business, whether they are making or losing money, they must likewise keep books. It is true that many farmers keep books, and the number of those who keep books is increasing.

The advantages of keeping books on the farm are as follows:

1. It makes farming systematic. Farmers are enabled to know their financial standing and progress.

2. Cost accounts enable the farmer to know what crops and what animals and what farm operations are making money. Many times farmers do not know which farm operations are profitable, and which ones are not. Farm bookkeeping corrects opinions.

3. Farm bookkeeping brings more net returns in proportion to the time spent upon it than other farm operations.

4. Farm bookkeeping is not difficult and does not require much time.

What books to keep. — Books kept upon the farm should be simple, and adapted to the conditions and needs of the individual farmer. Whatever books are kept should be kept systematically. The following separate books should be kept:

1. An annual inventory.
2. Cost accounts in production of different crops.
3. Cost of keeping farm animals.
4. An itemized statement of receipts and the total receipts for the year.
5. An itemized statement of expenditures and the total expenditures for the year.
6. Profits for the year.

The farm inventory. — While the farm inventory may be taken at any season of the year, it is suggested that it be taken January 1st, for *the amount of things on hand is at the lowest ebb at that time of the year*, and the farmers usually have more spare time at this season. March and April are also good months for taking an inventory. The farm inventory should be made conservatively. Nothing should be estimated at values too high. To ascribe exorbitant values defeats the purpose for which books are kept.

The following things should be included in the inventory:

1. Land.
2. Farm buildings.
3. Live stock.
4. Machinery.
5. Feed and supplies.

The opposite outline illustrates the inventory of a farm.

This inventory indicates that the money invested in land was $6240, in buildings $2590, in machinery $393, in farm animals $1848 and in feed $926. The per cent of money invested in each department of the farm can be easily figured from the above data. The column on the right is provided so that the inventories for two years may be placed on the same sheet. This gives a better chance for comparison.

The above farm, since it has $11,997 of capital invested, should bring greater returns than a farm in which only a small amount of capital is invested. If money is worth 5 per cent, the above farm should have receipts equal to $599.85 interest on the invested capital, plus a fair labor income.

Form for keeping farm records. — Forms on which records are kept vary. An egg record, the record of a dairy cow and the record of a flock of sheep all vary in form. A yearly egg record for a flock of fowls may be kept as shown on page 567.

The form for keeping an account of the milk yielded by 18 dairy cows for a year is shown in the following.

Invoice of Spring Valley Farm

January 1, 1920

January 1, 1920				January 1, 1921		
Number and Amount	Value	Total Value	Grand Total	Number and Amount	Value	Total Value
Land.						
208 acres . . .	$ 30	$6240	$ 6,240			
Buildings.						
1 house		1250				
2 barns		875				
Poultry house . .		125				
Other buildings .		340	2,590			
Machinery.						
1 big wagon . .		50				
1 spring wagon .		75				
1 self binder . .		80				
1 mower . . .		35				
2 plows	10	20				
2 harrows . . .	9	18				
2 cultivators . .	15	30				
1 hay rake . . .		10				
1 wheat drill . .		40				
1 corn planter . .		35	393			
Farm animals.						
4 horses	104	416				
2 mules	140	280				
12 beef cattle . .	40	480				
30 hogs	12	360				
25 sheep	10	250				
125 chickens . .	0.50	62.50	1,848.50			
Feed.						
400 bushels corn .	1.25	500				
80 bushels oats . .	.70	56				
10 tons timothy hay	15.00	150				
5 tons alfalfa . .	20.00	100				
30 tons straw . .	4.00	120	926			
Grand total . .			$11,997.50			

Date	Jan.		Feb.		Mar.		April		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
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28																								
29																								
30																								
31																								
Total Dozen Value																								

Fig. 199. — Egg record.

MILK RECORD FOR THE MONTH ENDING ______________ 191

	NAME AND NUMBER OF ANIMAL																		
1 AM																			
PM																			
2 AM																			
PM																			
3 AM																			
PM																			
4 AM																			
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31 AM																			
PM																			
TOTAL FOR MONTH																			
PER CENT. FAT																			

FIG. 200. — Milk sheet.

A pasteboard 16 inches wide and 24 inches long, properly lined, makes an excellent sheet on which to keep temporary records. However, all records, or at least a summary of them, should finally be transferred to a permanent book.

Cost accounts. — Cost accounts in the production of various farm crops should be kept. The accounts should be simple and inclusive. All cost accounts are estimates of the cost of production. The cost of production varies with seasons, scarcity of labor, number of horses used, kind and size of machinery used, value of land, interest value of money, and the yield of the crop.

Average yields per acre in U. S., and used in the estimates, is about as follows:

Corn	27.2 bushels	1906–1915 inclusive.
Wheat	13.2 bushels	
Oats	26.1 bushels	
Alfalfa	2.14 tons	

In the above outline a day was considered as 10 hours; man labor was figured at 30 cents an hour, and horse labor at 15 cents an hour. All estimates as to yields are based upon averages as given in the U. S. Yearbook of Agriculture.

The wear and tear and depreciation on machinery are not included in the above estimates.

The cost of production on the above farm is, — corn $528, alfalfa $470, wheat $562.50, oats $516.22, and pasture $204; or the total cost is $2280.72. This is an estimate. That the total cost may in many cases be greater no one questions. In some instances it may be less.

The income from the above farm varies with yields, prices, cost of production, money invested, etc.

Farm receipts. — The receipts represent the income, the amounts received upon the farm. The sources of income are the sales of grains, hay, live stock, dairy products, poultry and other miscellaneous things. If the invoice increases, the additional increase in the inventory is added to the farm receipts. For illustration, if the building of a railroad enhances the price of the farm land $10 per acre, it augments the inventory just that much.

The following plan suggested in Farmer's Bulletin No. 511 is suggestive on keeping records of the income.

COST OF CROP PRODUCTION, 1918 — 160 ACRE FARM

Corn, 30 Acres

	Man Labor in Hours	Horse Labor in Hours	Cost Man Labor	Cost Horse Labor	Total Cost
1. Seed 4 bu. @ $3					$ 12.00
2. Plowing 20 days	200	400	$ 60	$ 60	120.00
3. Two harrowings	60	120	18	18	36.00
4. Planting	40	80	12	12	24.00
5. 4 cultivations	160	320	48	48	96.00
6. Harvesting	100	200	30	30	60.00
7. Interest on $ 3000 @ 6 % or rent					180.00
Total					$ 528.00

Pasture, 30 Acres

Interest on land, $ 3000 @ 6 %	$ 180
Mowing weeds	24
Total	$ 204

Alfalfa, 30 Acres

	Man Labor in Hours	Horse Labor in Hours	Cost Man Labor	Cost Horse Labor	Total Cost
Three cuttings, 3 days each	90	180	$ 27	$ 27	$ 54.00
Haying, 6 days each, 3 men, 2 horses	540	360	182	54	236.00
Interest on money $ 3000 @ 6 % or rent					180.00
Total					$ 470.00

Wheat, 30 Acres

	Man Labor in Hours	Horse Labor in Hours	Cost Man Labor	Cost Horse Labor	Total Cost
Seed 45 bu. @ $ 3					$ 90.00
Plowing 2 days	200	400	$ 60	$ 60	120.00
Harrowing, 4 times	120	240	36	36	72.00
Planting	40	80	12	12	24.00
Harvesting, 3 men	100	150	30	22.50	52.50
Threshing, 8 ¢ per bu.					224.00
Interest on money @ 6 % or rent					180.00
Total					$ 562.50

Oats, 30 Acres

	Man Labor in Hours	Horse Labor in Hours	Cost Man Labor	Cost Horse Labor	Total Cost
Seed 60 bu.					$ 45.00
Plowing	200	400	$ 60	$ 60	120.00
Harrowing, 2 times	60	120	18	18	36.00
Drilling	40	80	12	12	24.00
Harvesting	100	150	30	22.50	52.50
Threshing, 783 bu. @ 7½ ¢					59.72
Interest on money					180.00
Total					$ 516.22

Farmstead, 10 Acres

ONE METHOD OF KEEPING CASH RECEIPTS

1911				
April	2	20 bushels potatoes at 60 cents	$12.00	
"	2	18 dozen eggs at 21 cents . .	3.78	
"	7	2 tons hay at $16.00 . . .	32.00	
"	7	1 cow to J. Brown	47.50	
"	7	30 dozen eggs at 20 cents . .	6.00	
"	7	3 bushels seed potatoes at $1.00	3.00	$104.28

This is a good method of keeping the income account. There is only one criticism of this method. It combines all the accounts from various sources. It is possibly better to classify the sources of income, and to keep the receipts from grain, live stock, poultry products, etc., separately. The following suggestion taken from the same bulletin gives an idea of a classified method of keeping income accounts

CLASSIFIED METHOD OF KEEPING RECEIPTS

1911			DAIRY	POULTRY	CROPS	GENERAL
April	2	2 yearlings to Jones .	$35.00			
"	3	2 tons of hay to Brown			$32.00	
"	4	14 dozen eggs at 25 cents		$3.50		

The above form when carried into greater detail is a good way of keeping income accounts.

On the other hand farmers may desire to keep the receipt accounts from various sources on separate sheets. This is possibly the most satisfactory method of keeping income receipt accounts. With this method each item can be quickly estimated as to its profitableness, especially if the expenditures upon it are known.

Farm expenditures. — Money paid for food, clothing, machinery, feed stuffs, repair, etc., are farm expenditures. If money is paid

out for philanthropic purposes, it should not be counted against the farm.

If the invoice of the farm is lowered, or if some land is sold, it is considered as an expenditure. For illustration, if 40 acres of land are sold for $4000, the expenditure is counted as $4000 and the income is likewise counted as $4000. Abstractly speaking, there was neither a gain nor a loss. But if on the other hand the 40 acres was correctly invoiced the preceding year at $3000, then the profit was $1000. The point is this, if the invoice is lowered, it must be considered an expenditure.

Farm expenditures may be kept in forms like those used for receipts. The following, from Farmer's Bulletin No. 511, is suggestive:

EXPENDITURES

1911				
April	2	1 ton cotton-seed meal for dairy	$35.00	
"	2	Strap for work harness . . .	.3	
"	2	Personal	2.25	
"	2	Household	1.60	
"	7	Garden seed	8.00	
"	7	Express on seeds	.85	
"	7	2 milk pails	2.00	
"	7	Household	.86	
"	7	Repairing plow	1.20	$52.11

The above suggestion is good, but it bunches too many items. Separating items according to the following suggestion from the same bulletin may be better.

EXPENDITURES

1911		Item	Dairy	Poultry	Crops	General
April	2	1 ton wheat bran . .	$28.00			
"	2	10 bushels oats at $1.00			$10.00	
"	7	2 bags chicken wheat .		$2.50		

Many farmers may desire to still further separate expense accounts by keeping separate accounts of every crop, of every type of farm animal, and of household expenditures.

Profits. — By profits we mean the farm receipts, minus the expenditures and a fair rate of interest on the investment. Algebraically stated: Profits = Receipts − (Expenditures + Interest on the Capital). Many times farmers call the income the profits, not considering the capital invested nor the expenditures. A farmer having $10,000 invested in a farm must have an income of $500 above all expenses, if money is worth 5 per cent, before he has a penny of profit. On the other hand, if he has an income of $1500 over all expenses except interest on the capital, then his profit is $1000. If the same farmer has no capital, then an income of $500 above all expenditures would represent his yearly labor income, or his profit.

A crop yields a profit to the extent of the receipts received for it over the cost of production, counting the interest on the money invested as a part of the cost of production. To illustrate, if it costs $528 to produce 30 acres of corn, and the corn is sold for $580, then the profit is $52, about 10 per cent. If it costs $1000 to keep 20 dairy cows for one year, — interest, depreciation, etc., included, — and the products sell for $1100, a profit of $100 is made.

If the invoice increases without any expenditures, such an increase must be counted as profit. It is for this reason that we must have the invoice of the farm, yearly receipts and yearly expenditures, if we are to figure profits correctly.

Summary. — Farm bookkeeping is becoming more common because it is helping to make the farmer more efficient, and the farm more productive. If the farmer is to know whether his farm is profitable or not, he must keep an inventory from year to year, and also an account of his expenditures and his receipts. He cannot figure his profits or losses accurately unless he includes in his expenditures a fair rate of interest on his investment.

It is also important that accounts be kept with the different

crops produced and animals kept. If we are to know what particular farm operations make most profit, we must know what the total expenditures and receipts are upon the production of the same. Checking up takes the guess out of any farm operation. Farm bookkeeping eliminates largely the unprofitable farm operations and hence is an important factor in making the farm more productive, profitable and satisfactory.

QUESTIONS

1. Why keep books on the farm?
2. What books should be kept and why?
3. What is an inventory?
4. What are cost accounts? Why are they estimates only?
5. Why must a man with a large capital have a larger income than a man with a small capital?
6. What is a fair yearly income above the interest on the capital invested?

PROBLEMS FOR THE CLASS AS A GROUP

1. Make an invoice of some farm on the blackboard, and find the per cent of money invested in land, buildings, machinery, live stock and feeds.
2. Get the profits made by farmers on the production of corn, wheat and oats.

REFERENCES

Warren, Farm Management.
Boss, Farm Management.
Farmer's Bulletin No. 511.

CHAPTER XLI

CHOOSING A FARM

Considerations in the choice of a farm. — Every community indicates the degree of prosperity it enjoys. Prosperous communities usually have good homes and barns, good horses and cattle, good schools and churches, good roads and prosperous business houses. The buildings, fences and roads are in good repair. On the other hand, a community which does not enjoy prosperity usually has inferior farm machinery, scrub live stock, plants that produce at a low rate and schools and churches that show a lack of paint and repair. The old saying that a community should show its prosperity may well be remembered when high prices are asked for land.

There are two chief considerations in the purchase of a farm. These are: First, will the farm yield adequate economic returns? And, second, do the farm and the locality afford the conditions essential for the building of a satisfactory home?

Considerations of a farm for money-making. — The *healthfulness* of a locality affects the value of a farm as an asset for money-making. Some of the swamp lands have conditions which are unhealthful, and hence to locate in these sections invites failure.

The soil is the basis for plant and animal production. A rich soil produces large crops; and large crops are essential to animal production. The texture, structure, amount of organic matter, depth and character of soil and subsoil, the kind of vegetation, topography of the soil, ease with which the soil may be cultivated, size and shape of fields, adaptability to the crops grown in the community and the capacity of the soil to retain its fertility are all important considerations in the selection of a farm.

The soil is the final source of income. If every member of the family is to be satisfied, there must be a reasonable income in order that the necessities of life may be purchased. By necessities of life we would include more than food, clothing, and shelter. An education, some recreation, and amusement may well be included in the necessities of life. The products of the soil must furnish the income of the farm.

Some soils will grow 20, some 50 and some 75 bushels of corn per acre. In addition the soil having the highest producing capacity usually produces larger yields over a greater number of years. Productive fertile soils are an ever responsive asset; waste lands are often a liability.

Farm buildings, in size and repair, are usually in harmony with the general appearances of the rest of the farm. In many localities the barns and outbuildings are better, comparatively speaking, than the dwelling houses. Barns and stables should have sufficient room; they should be properly lighted and ventilated; they should be comfortably dry; they should be in good repair and provide those conditions which produce the greatest growth and comfort at a reasonable cost.

The farm home deserves more consideration than it has received in the past. Convenience, comfortableness, healthfulness and sufficient room are essential to a satisfactory home.

Good homes will pay big dividends in contentment and satisfaction. The picture on page 576 shows conditions which tend to keep boys and girls, men and women, on farms.

The best authorities agree that it is unwise from an economic standpoint to invest more than 25 per cent of the aggregate value of the farm in farm buildings.

Good markets mean much in the choice of a farm. Roads which are passable for three hundred and sixty-five days in the year save time and enable the farmer to market his products at any time of the year. Such roads reduce the cost of transportation and hence widen the margin between cost of production and the selling price. Good roads save enough that the savings will supply

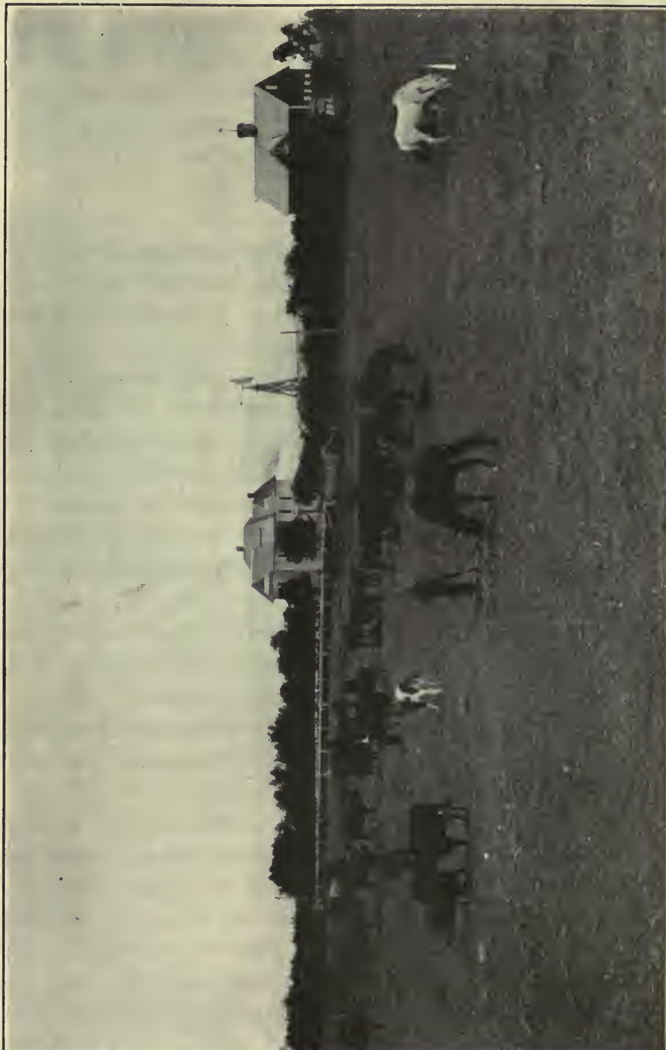

FIG. 201. — A good country house.

sufficient funds to build them. The time required to go to market is more important than the distance. In some instances it requires less time to drive 5 miles with a car than one mile with a horse. In addition the auto truck will haul 4 times as much as can be hauled in the wagon.

Dairy, truck, and floral farms should be near a good market; grain farms may be farther removed; and the live stock farm may be still farther away. Railroad facilities enhance farm values.

Kind of farming is predetermined to some extent by the kind of soils. Some soils are adapted to grass, some to hay crops, others to a diversification of grasses, field crops and live stock. The kind of farming practiced should be suited to the land.

Consideration of a farm for home building. — The choice of a farm for building a home which is satisfactory to every member of the family is very important; even as important as the choice of a farm from an economic aspect.

The neighborhood should be congenial, progressive and coöperative. The kind of stock kept enhances the value and desirability of a community. But cattle are cattle. The children of a neighborhood are more important; for the language spoken and the morals and ideals of the children have a tendency to seek a common level. The children will be associated together in school, in church, in the home and upon the playground. The ideals of the neighbors and their children make a locality desirable or undesirable.

Educational advantages are worth much. The lack of school facilities has often caused neighbors to move elsewhere. Some of the most desirable citizens are thus often lost. This lowers the assets of the locality, for good neighbors are worth much to a community, because they help to elevate morals and ideals, and even increase the value of the land. Often these neighbors leave because of the lack of educational, religious and social advantages.

The liberal support of elementary schools, and the establishment and maintenance of first-class high schools is not only an educational asset, but a financial asset as well. It is true that some of our leaders and statesmen have come from localities where

educational facilities were not good; they rose despite the fact that their chances were somewhat curtailed.

From a business standpoint, it is well to give people an education. Ignorant people have few wants, usually have a low earning power, and hence will purchase only a relatively small amount of foodstuffs and clothing. Their purchases are limited. On the other hand, an education increases one's wants and hence produces a citizen who purchases more things. He buys more clothing, more food, more conveniences, and hence makes a more desirable citizen. It is realized more and more that ignorance is the most expensive commodity, not only to the individual, but to the community as well. It is for this reason that good schools often increase the price of land $5.00 to $10.00 per acre. Schools have other advantages which cannot be measured in money.

Religious advantages are quite as important as are schools. Religious instruction and development of an undenominational kind deserves more attention than it has received in the past. In the country districts and in small villages a federated church, combining all denominations, is feasible and desirable. Divisions and separations have resulted in inefficiency. Coöperative efforts give strength. The federated church is more efficient religiously, socially, morally and financially, and hence is certain to replace the sectarian church. It is not denominational development that is needed so much as Christian development.

The school is the center of community life and therefore may in many cases be so constructed as to furnish excellent facilities not only for Sunday School work, but also for other church activities.

Ideals express themselves in the morals and sentiment of the community. The ideals of a community permeate the life of the school, church and home. The presence of desirable institutions characterizes a community of high ideals. On the other hand, the presence of undesirable institutions is significant evidence of low ideals. Good music and wholesome amusements prevail in a community of high ideals.

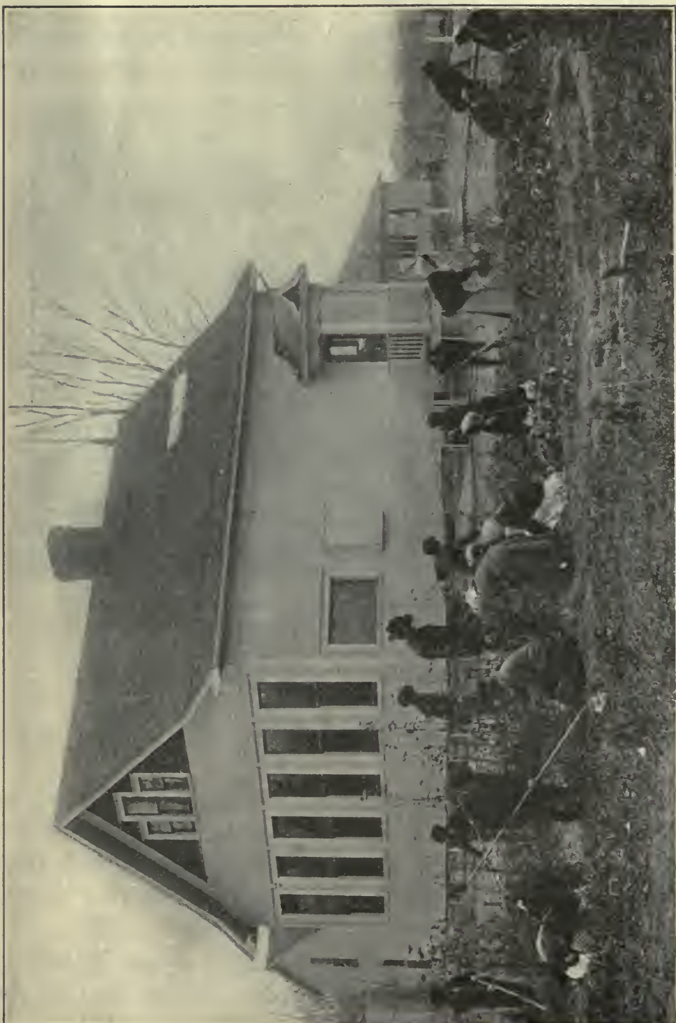

FIG. 202. — A consolidated school community where transportation is used to convey pupils to school. Many important meetings are held on the school grounds and in the school building.

Community coöperation is essential to the best development of any locality. The best in life cannot be had without coöperation. Good churches and schools, and high ideals of a community, are due to coöperation. The federated church, a strong school

FIG. 203. — A federated church. The church is attractive and is an important factor in the progressive movements of the community.

spirit, farmers' organizations, boys' and girls' clubs and literary societies tend to bring coöperation. Often the Grange, a cow-testing association, a club of some sort, or a literary society has united a community.

Growing one breed of live stock or of poultry or even a definite variety of plants may often become the nucleus of a coöperative spirit. United action means power and progress. It is helpful educationally, socially and financially. The best institutions are the result of community coöperation.

Summary. — In choosing a farm two things should be kept in mind: First, will the farm yield sufficient returns so that the necessities of life may be had? The chief factors that affect money making on the farm are: healthfulness of the locality,

the soil, the comparative amount of money invested in buildings, and the comfortableness of the same, good markets and roads, and adapting the type of farming to the soil. Second, will the farm and community yield itself to the building of a good home? The chief considerations in home building are the neighbors, educational and religious advantages, the ideals of the people of the community and community coöperation. All of these factors are important in the choice of a farm and the building of a home.

QUESTIONS

1. What are the chief considerations in the choice of a farm from an economic standpoint?
2. Name and discuss the factors which help in building a good home.

PROBLEMS

1. Report upon the work and value of some institution or organization found in your community.
2. Report upon your locality, as being a good locality in which to purchase a farm, applying the main considerations of this chapter.

REFERENCES

Warren, Farm Management.
Boss, Farm Management.
Gehrs, Productive Agriculture.

APPENDIX

THE STATE AGRICULTURAL EXPERIMENT STATIONS

Alabama —
  College Station: AUBURN
  Canebrake Station: UNIONTOWN
  Tuskegee: TUSKEGEE
Arizona — TUCSON
Arkansas — FAYETTEVILLE
California — BERKELEY
Colorado — FORT COLLINS
Connecticut —
  State Station: NEW HAVEN
  Storrs Station: STORRS
Delaware — NEWARK
Florida — GAINESVILLE
Georgia — EXPERIMENT
Idaho — MOSCOW
Illinois — URBANA
Indiana — LAFAYETTE
Iowa — AMES
Kansas — MANHATTAN
Kentucky — LEXINGTON
Louisiana —
  State Station: BATON ROUGE
  Sugar Station: AUDUBON PARK,
  North La. Station: CALHOUN
  Rice Station: CROWLEY
Maine — ORONO
Maryland — COLLEGE PARK
Massachusetts — AMHERST
Michigan — EAST LANSING
Minnesota — ST. ANTHONY PARK, ST. PAUL
Mississippi — AGRICULTURAL COLLEGE
Missouri —
  College Station: COLUMBIA
Missouri —
  Fruit Station: MOUNTAIN GROVE
Montana — BOZEMAN
Nebraska — LINCOLN
Nevada — RENO
New Hampshire — DURHAM
New Jersey — NEW BRUNSWICK
New Mexico — AGRICULTURAL COLLEGE
New York —
  State Station: GENEVA
  Cornell Station: ITHACA
North Carolina —
  College Station: WEST RALEIGH
  State Station: RALEIGH
North Dakota — AGRICULTURAL COLLEGE
Ohio — WOOSTER
  COLLEGE OF AGRICULTURE
  COLUMBUS
Oklahoma — STILLWATER
Oregon — CORVALLIS
Pennsylvania — STATE COLLEGE
Rhode Island — KINGSTON
South Carolina — CLEMSON COLLEGE
South Dakota — BROOKINGS
Tennessee — KNOXVILLE
Texas — COLLEGE STATION
Utah — LOGAN
Vermont — BURLINGTON
Virginia — BLACKSBURG
Washington — PULLMAN
West Virginia — MORGANTOWN
Wisconsin — MADISON
Wyoming — LARAMIE

The United States Department of Agriculture is made up of many bureaus, all of which publish interesting and valuable farm literature. These publications may be had through your Congressman or from the Secretary of Agriculture, Washington, D. C. A few of these bureaus are:

Bureau of Animal Industry
Bureau of Chemistry
Bureau of Entomology
Bureau of Biological Survey
Forest Service
Office of Experiment Stations
Bureau of Plant Industry
Bureau of Statistics
Bureau of Soils
Weather Bureau
Division of Publications
Office of Public Road Inquiries.

LEGAL WEIGHTS PER BUSHEL OF SOME FARM PRODUCTS

NAME OF MATERIAL	WEIGHT IN POUNDS	NAME OF MATERIAL	WEIGHT IN POUNDS
Alfalfa	60	Kentucky blue-grass	14
Apples	48	Millet	50
Apples (dried)	24	Oats	32
Barley	48	Onions	57
Beans	60	Peas	60
Buckwheat	52	Potatoes (Irish)	60
Carrots	50	Potatoes (sweet)	55
Clover seed	60	Rye	56
Corn (ear)	70	Timothy seed	45
Corn (shelled)	56	Turnips	55
Cotton seed	32	Wheat	60
Flax seed	56		

Yearbook of United States Department of Agriculture.

AVERAGE WEIGHT OF SOME FEEDING STUFFS

	WEIGHT OF ONE QUART POUNDS
Wheat bran	0.5
Wheat middlings	0.8
Wheat, whole	2.0
Oats (whole)	1.0
Linseed meal (old process)	1.1
Cotton-seed meal	1.5
Corn (whole)	1.7
Milk	2.145

Farm papers. — Schools will occasionally have need for the addresses of agricultural papers. The following papers are representative and helpful to school work.

Wallace's Farmer, Des Moines, Iowa, weekly	$1.00
Breeders Gazette, Chicago, Ill., weekly	$1.75
Hoard's Dairyman, Fort Atkinson, Wis., weekly	$1.00
Kimball's Dairy Farmer, Waterloo, Iowa, semiweekly	$1.00
Reliable Poultry Journal, Quincy, Ill., weekly	$ .50
The Swine World, Frost Pub. Co., Chicago, Ill., weekly	$1.00

Papers on specific breeds of live stock and poultry may be had by writing to the breed associations. Each state usually publishes farm papers which are of local interest.

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